Sandia National Laboratories / New Mexico

PROPOSAL FOR NO FURTHER ACTION ENVIRONMENTAL RESTORATION PROJECT SITE 230, STORM DRAIN SYSTEM OUTFALL SITE OPERABLE UNIT 1309

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Environmental
Restoration
Project

United States Department of Energy
Albuquerque Operations Office

PROPOSAL FOR NO FURTHER ACTION

Site 230, Storm Drain System Outfall Site
Operable Unit 1309

SANDIA NATIONAL LABORATORIES/NEW MEXICO

1. Introduction

1.1 ER Site Identification Number and Name

Sandia National Laboratories/New Mexico (SNL/NM) is proposing a risk-based no further action (NFA) decision for Environmental Restoration (ER) Site 230, Storm Drain System Outfall Site, Operable Unit (OU) 1309. ER Site 230 is listed in the Hazardous and Solid Waste Amendment (HSWA) Module IV (EPA August 1993) of the SNL/NM Resource Conservation and Recovery Act (RCRA) Hazardous Waste Management Facility Permit (NM5890110518) (EPA August 1992).

1.2 SNL/NM Risk-based NFA Process

This proposal for a determination of an NFA decision has been prepared using the criteria presented in Section 4.5.3 of the SNL/NM Program Implementation Plan (PIP) (SNL/NM February 1994). Specifically, this proposal will "contain information demonstrating that this SWMU has never contained constituents of concern that may pose a threat to human health or the environment" [as proposed in the Code of Federal Regulations (CFR), Section 40 Part 264.51(a) (2)] (EPA July 1990). The HSWA Module IV contains the same requirements for an NFA demonstration:

> Based on the results of the RFI [RCRA Facility Investigation] and other relevant information, the Permittee may submit an application to the Administrative Authority for a Class III permit modification under 40 CFR 270.42(c) to terminate the RFI/CMS [corrective measures study] process for a specific unit. This permit modification application must contain information demonstrating that there are no releases of hazardous waste including hazardous constituents from a particular SWMU at the facility that pose threats to human health and/or the environment, as well as additional information required in 40 CFR 270.42(c) (EPA August 1993).

For a risk-based proposal, an SWMU is eligible for an NFA determination if the NFA criterion established by the SNL/NM permit is met. This criterion, found in Section M.1 of the permit, is as follows: "[T]here are no releases of hazardous waste including hazardous constituents...that pose threats to human health and/or the environment..." This risk-base proposal contains information needed to make the NFA determination.

This proposal is using the technical approach which is the foundation for the SNL/NM corrective action process. The details of the SNL/NM technical approach are provided in Appendix C of the PIP. The first step in the technical approach is the data qualitative review step (the same step used to determine whether the SWMU is eligible for administrative NFA). Should significant uncertainties remain, the assessment of the SWMU continues within the SNL/NM technical approach.

At this site, sufficient data were not available to compare to established action levels or develop site-specific action levels. Background soil samples were collected and analyzed to develop upper tolerance limits (UTLs) for metals. Site-specific data were collected to compare to existing soil action levels (proposed subpart S action levels) and UTLs. If site-specific concentrations exceeded the proposed Subpart S action levels or UTLs, then a risk assessment was performed. The site-specific concentrations were compared to the derived risk assessment action levels. Concentrations less than these action levels, either proposed Subpart S action levels, UTLs, or derived risk-based values, triggered this NFA proposal for Site 230.

1.3 Local Setting

SNL/NM occupies 2,829 acres of land owned by the Department of Energy (DOE), with an additional 14,920 acres of land provided by land-use permits with Kirtland Air Force Base (KAFB), the United States Forest Service, the State of New Mexico, and the Isleta Indian Reservation. SNL/NM has been involved in nuclear weapons research, component development, assembly, testing, and other nuclear activities since 1945.

ER Site 230 (Figure 1) is located on land owned by DOE. The outfall is located along the northern embankment of Tijeras Arroyo and is situated west of Building 970 in Technical Area (TA) IV.

Surficial deposits in the SNL/KAFB area lie within four geomorphic provinces, which in turn contain nine geomorphic subprovinces. Site 230 lies within the Tijeras Arroyo subprovince. The Tijeras Arroyo subprovince is characterized by broad, west-sloping alluvial surfaces and the 50-meter-deep Tijeras Arroyo. The Tijeras Arroyo subprovince contains deposits derived from many sources, including granitic and sedimentary rocks of the Sandia Mountains, sedimentary and metamorphic rocks of the Manzanita Mountains, and sediments of the Upper Santa Fe Group.

2. History of the SWMU

2.1 Sources of Supporting Information

In support of the request for a risk-based NFA decision for ER Site 230, a background study was conducted to collect available and relevant site information. Interviews were conducted with SNL/NM staff and contractors familiar with site operational history.

The following information sources were available for the use in the evaluation of ER Site 230:

- Confirmatory-sampling program conducted in September 1994
- Risk analysis for two metals and one radionuclide
- One surface radiation survey
- One unexploded ordnance/high explosives (UXO/HE) survey
- Interviews and personnel correspondence
- Historical aerial photographs spanning 40 years

2.2 Previous Audits, Inspections, and Findings

In November 1993, the Sandia ER staff recognized Site 230 as an SWMU. ER Site 230 was not listed as a potential release site based on the Comprehensive Environmental Assessment and Response Program (CEARP) interviews in 1985 (DOE September 1987). In addition, Site 230 was not included in the Environmental Protection Agency (EPA) RCRA Facility Assessment (RFA) in 1987 (EPA April 1987) and Site 230 was not included in the Hazard Ranking System (DOE September 1987).

2.3 Historical Operations

The outfall discharged industrial effluent and storm water from TA-IV (Figure 1). Currently, the outfall discharges only storm water. The specific constituents in the industrial effluent are not known. The possible discharge contaminants include chromates, antifoulants, chromium, sodium hydroxide, hydrochloric acid, chromosulfuric acid, diesel, and other petroleum products. Mineral oil is also being considered a potential soil contaminant due to a recent release (June 1994) of mineral oil at a similar outfall, Site 232.

3. Evaluation of Relevant Evidence

3.1 Unit Characteristics

The Storm Drain System Outfall is confined to the downstream natural drainage. All releases would be contained in this limited area.

3.2 Operating Practices

Based on interviews and personnel correspondence, the outfall discharged industrial effluent and storm water from approximately 1984 to 1991. Examination of aerial photographs confirms this time frame but provides no additional information.

3.3 Presence or Absence of Visual Evidence

The approximately 75-foot long outfall and the cement culvert are the only physical evidence of the outfall system. No discoloration of soils was observed during site reconnaissance and soil sampling activities.

3.4 Results of Previous Sampling/Surveys

In 1994, the site was visually surveyed for surface indications of UXO/HE. No UXO/HE were found (SNL/NM 1994a). Also in 1994, a surface radiation survey was conducted on the entire site using an Eberline ESP-2 portable scaler, with an Eberline SPA-8 (2 inch X 2 inch sodium iodide) detector. A 30-second integrated count was performed at each proposed sample location, while scanning the detector over an area approximately 2 feet in radius around the sample location. The alarm was set at 1.3 times the background count rate. No alarms occurred during the survey. No surface anomalies were detected (SNL/NM 1994b).

3.5 Assessment of Gaps in Information

No environmental sampling data existed for Site 230. If contamination was present, potential constituents of concern (metals, radioactive constituents, and organic constituents) would be expected at shallow depths. Metals and radioactive constituents generally adsorb on soil and precipitate rather than remaining soluble. If organic constituents were introduced in the drainage, they should be detectable in surface or shallow subsurface soils.

3.6 Confirmatory Sampling

A surface (0-6 inches deep) and shallow subsurface (6-36 inches deep) soil sampling program was developed and implemented in September 1994. The Confirmatory Sampling and Analysis Plan (SAP) can be found in Appendix A. Those soil sample results exceeding an action level are summarized in Table 1. A complete list of "hits" or detections and quality assurance (QA) results can be found in Appendix B.

For health and safety purposes, a photo-ionization detector, OVM, was used throughout the field program. The OVM measured no anomalous vapor concentrations.

Surface and shallow subsurface soil samples were collected at the most likely locations of contamination. Four samples were collected at the outfall and four samples were collected at the furthest extent of visible erosion and scour (Figure 1). Every sample was analyzed for target analyte list (TAL) metals[1], chromium^{+6}, and total petroleum hydrocarbon (TPH). The four subsurface samples also were analyzed for volatile organic compounds (VOCs). Four samples were analyzed for semivolatile organic compounds (SVOCs). As a general check for radioactive constituents, two samples were analyzed for tritium, one sample was analyzed for isotopic uranium and plutonium, and four samples were screened with in-house gamma spectroscopy.

3.6.1 Background Samples for Metals and Radioactive Constituents

UTLs for background metals were calculated from analyses of 24 samples collected in the vicinity of the 11 sites discussed in the SAP (Appendix A). UTLs or background 95th percentiles for background radionuclides were calculated from samples collected throughout KAFB (IT 1994). A discussion of background calculations and supporting data and analyses are included in Appendices C and D.

3.6.2 Organic Compounds

No organic compounds were detected positively; di-n-octyl phthalate was detected in one of four samples but was below the reportable limit (qualified with a "J" in Table 1) and 2-butanone was detected in all four samples but was qualified with a "J" and "B". None of these qualified detections indicate significant contamination. TPH was detected in three of the

[1] Although the TAL metal analytes include calcium, magnesium, potassium, and sodium, these nontoxic, major cations are not included in the evaluation. They do not pose a significant environmental or human health risk regardless of concentration.

eight samples. All three of these detections were at concentrations above 100 milligrams per kilogram (mg/kg) (110, 110, and 120 mg/kg). These relatively low and isolated detections of TPH do not indicate significant contamination.

3.6.3 Metals

Mercury, selenium, silver, and chromium^{+6} were not detected at Site 230. The maximum local background value for beryllium was 0.53 mg/kg. Beryllium was not detected above 0.53 mg/kg. All other metal concentrations except one analysis for copper and all eight analyses for zinc were below UTLs. Sample 230-04-B had a copper concentration of 18 mg/kg, compared to a UTL for copper of 13.6 mg/kg. The eight concentrations above the zinc UTL of 79 mg/kg ranged from 82 to 140 mg/kg. The proposed Subpart S action level for zinc is 20,000 mg/kg.

3.6.4 Radionuclides

Thallium was not detected at Site 230. Tritium, plutonium-239/240, and plutonium-238 were not detected above the minimum detectable activity (MDA). Uranium-238 and uranium-234 were detected at activities below the base-wide background 95th percentile of 1.1 and 1.0 picocuries per gram (pCi/g), respectively. Uranium-235/236 was detected in Sample 230-01-A at 0.23 pCi/g, compared to the base-wide background 95th percentile of 0.168 pCi/g and to the maximum local background value of 0.33 pCi/g.

3.6.5 Quality Assurance Results

As discussed in the Confirmatory Sampling and Analysis Plan (Appendix A), quality assurance samples, including field duplicates, trip blanks and rinsates, were collected as part of the 11-site sampling program. Analyses indicate that the field soil duplicates were comparable to the original soil sample results. The trip blanks and rinsates indicated no significant sampling contamination. QA results can be found in Appendix B. Level I and Level II data verification was conducted on all data, as described in the PIP (SNL/NM 1994).

3.7 Risk Analysis

To further evaluate the metals data for metals with concentrations greater than background UTLs, a risk assessment was performed for a combination of copper and zinc, assuming the maximum detected concentrations. To further evaluate the site data for radionuclides with activities above background UTLs, 95th percentiles, or those without background UTLs, a risk assessment was performed for uranium-235/236, assuming the maximum detected activity.

The risk calculations were designed to produce conservatively large estimates of hazard index and radioactive dose to counter uncertainties in the soil data. This approach facilitates the following decision regarding future activities at Site 230:

- If the conservative estimates based on the soil data result in an unacceptable hazard index (greater than 1) or dose (greater than 10 mrem/year), further investigation and/or remediation will be needed; or

- If the hazard index and dose estimates are acceptable, the potential for health hazards at the site is extremely low, and further actions will not be needed.

Hazard indices and radionuclide doses were computed using methods and equations promulgated in proposed RCRA Subpart S documentation (EPA 1990). Accordingly, all calculations were based on the assumption that receptor doses from both toxic metals and radionuclides result from ingestion of contaminated soil.

Calculation of hazard indices required values of oral reference doses (oral RfDs) for each of the metals. The RfD value for zinc was taken from EPA's IRIS database (IRIS 1994). An estimated RfD for copper was computed using a maximum contaminant level (MCL) of 1.3 mg/l and assuming that a 70-kg person consumes 2 liters of water a day.

Similarly, calculation of radionuclide doses required values of dose conversion factors, which are used to convert radionuclide intakes (in units of pCi/year) into effective dose equivalents (in units of mrem/year). A published value of dose conversion factor (Gilbert et al., 1989) exists for uranium-235/236.

To assure that the computed hazard indices and doses were conservatively large, only the maximum observed concentration of each constituent at a site was employed. To consider combined effects, a hazard index was calculated as the sum of the individual metal hazard quotients.

Following proposed Subpart S methodology, the equation and parameter values used to calculate the summed hazard index for toxic metals were:

$$HI = \sum_i [HSR(i) \times S(i)] \tag{1}$$

where:

HI	=	total hazard index (dimensionless),
HSR(I)	=	hazard index-to-soil concentration ratio for the ith metal (kg/mg)
	=	$\frac{I \times A}{RfD(i) \times W} \times \frac{0.001\ g}{mg}$
S(I)	=	soil concentration of the i^{th} metal (mg/kg),
I	=	soil ingestion rate = 0.2 g/day,
A	=	absorption factor (dimensionless) = 1,
W	=	body weight = 16 kg, and
RfD(I)	=	oral reference dose for the i^{th} metal (mg/kg-day).

Risk assessment guidance, prepared by the U.S. Environmental Protection Agency (EPA, 1989), recommends that the total hazard index be less than one in order for a site to be considered a non-threat to human health.

Following proposed Subpart S methodology, the equation and parameter values used to calculate the radioactive dose from one radionuclide was:

$$DOSE = DSR \times S \tag{2}$$

where:

DOSE	=	total effective dose equivalent (mrem/yr);
DSR	=	dose-to-soil concentration ratio for the radionuclide (mrem/yr)/(pCi/g),
	=	I X DCF;
S	=	soil concentration of the radionuclide (pCi/g);
I	=	soil ingestion rate = 0.2 g/day = 73 g/yr; and
DCF	=	dose conversion factor for the radionuclide (mrem/pCi).

The PIP stipulates that, for the purpose of computing media action levels, the total radioactive dose at a site should not be greater than 10 mrem/year (SNL/NM 1994), which corresponds to a cancer risk of less that 10^{-6} excess deaths.

The input and results of the risk calculations are presented in Tables 2 and 3. The summed hazard index for metals is less than one and the summed radioactive dose is less than 10 mrem/year. Therefore, the site is considered to be risk-free in terms of metals and radionuclide contamination.

3.8 Rationale for Pursuing a Risk-Based NFA Decision

Surface soil and shallow subsurface soil samples were collected at the "head" of the outfall (where the flow leaves the concrete flume and spills into the natural drainage) and at the furthest extent of visible erosion/scour where the discharged effluent would have most likely settled. These two areas are the most likely areas for contamination. SNL/NM is proposing a risk-based NFA because representative soil samples from ER Site 230 have concentrations less than action levels; either proposed Subpart S action levels, background UTLs, background 95th percentiles, or derived risk-based values.

In addition

- A site visit in 1993 by ER personnel confirmed the presence of a confined natural drainage with no discoloration in the soils.

- In June 1994, a UXO/HE visual survey was conducted by KAFB Explosive Ordnance Division (EOD) and found no UXO/HE ordnance debris at Site 230 (SNL/NM 1994a).

- In September, 1994, as part of the surface soil sampling effort at Site 230, a surface radiation survey was conducted (SNL/NM 1994b). No surface anomalies were detected at Site 230.

4. Conclusion

Based upon the evidence cited above, ER Site 230 has no releases of hazardous waste or hazardous constituents that pose a threat to human health and/or the environment. Therefore, ER Site 230 is recommended for an NFA determination.

5. References

5.1 ER Site References

Gilbert, T.L., C. Yu, Y.C. Yuan, A.J. Zielen, M.J. Jusko, and A. Wallo, 1989. *Implementing Residual Radioactive Material Guidelines, A Supplement to U.S. Department of Energy Guidelines for Residual Radioactive Material at Formerly Utilized Sites Remedial Action Program and Surplus Facilities Management Program Sites*, prepared by Argonne National Laboratory for U.S. Department of Energy, ANL/ES-160, DOE/CH/8901, 203 pp.

Guttman, I., 1970. *Statistical Tolerance Regions: Classical and Bayesian.* Hafner Publishing, Darien, Connecticut.

IRIS, Integrated Risk Information System (data base), 1994. U.S. Environmental Protection Agency, Office of Research and Development.

International Technology (IT) Corporation, 1994. Draft "Background Concentrations of Constituents of Concern to the Sandia National Laboratories/New Mexico Environmental Restoration Project Phase II: Interim Report,"

Sandia National Laboratories/New Mexico (SNL/NM), 1994a. "Unexploded Ordnance/High explosives (UXO/HE) Visual Survey of ER Sites Final Report, Sandia National Laboratories, Albuquerque, New Mexico."

Sandia National Laboratories/New Mexico (SNL/NM), 1994b. "Summary of Radiological Survey Results by SNL Dept. 7714 for ER Sites 50, 227, 229, 230-234," Sandia National Laboratories, Albuquerque, New Mexico.

U.S. Environmental Protection Agency (EPA), July 1990. "Corrective Action for Solid Waste Management Units (SWMU) at Hazardous Waste Management Facilities, Proposed Rule," *Federal Register*, Vol. 55, Title 40, Parts 264, 265, 270, and 271.

U.S. Environmental Protection Agency (EPA), 1989. "Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Addendum to Interim Final Guidance," U.S. Environmental Protection Agency, Office of Solid Waste, Waste Management Division, Washington DC.

U.S. Environmental Protection Agency (EPA), 1989. "Risk Assessment Guidance for Superfund: Volume I, Human Health Evaluation Manual (Part A)." Office of Emergency and Remedial Response, Washington, DC. 20460.

5.2 Reference Documents

U.S. Department of Energy (DOE), September 1987. "Comprehensive Environmental Assessment and Response Program, Phase I Insttallation Assessment Sandia National Laboratories - Albuquerque," Department of Energy Albuquerque Operations Office, Environmental Safety and Health Division, Environmental Program Branch, September 1987.

Sandia National Laboratories/New Mexico (SNL/NM), August 1994. Environmental Restoration Project Information Sheet for Site 230, Storm Drain System Outfall, Sandia National Laboratories, Albuquerque, New Mexico.

Sandia National Laboratories/New Mexico (SNL/NM), February 1994. Draft "Program Implementation Plan for Albuquerque Potential Release Sites," Sandia National Laboratories, Albuquerque, New Mexico.

U.S. Environmental Protection Agency (EPA), August 1993. "Module IV of RCRA Permit No. NM 5890110518, EPA Region VI, issued to Sandia National Laboratories, Albuquerque, New Mexico.

U.S. Environmental Protection Agency (EPA), August 1992. "Hazardous Waste Management Facility Permit No. NM5890110518, EPA Region VI, issued to Sandia National Laboratories, Albuquerque, New Mexico.

U.S. Environmental Protection Agency (EPA), April 1987, "Final RCRA Facility Assessment Report of Solid Waste Management Units at Sandia National Laboratories, Albuquerque, New Mexico," Contract No. 68-01-7038, EPA Region VI.

5.3 Aerial Photographs

Ebert & Associates, Inc., November 1994. "Photo-Interpretation and Digital Mapping of ER Sites 7,16,45,228 from Sequential Historical Aerial Photographs."

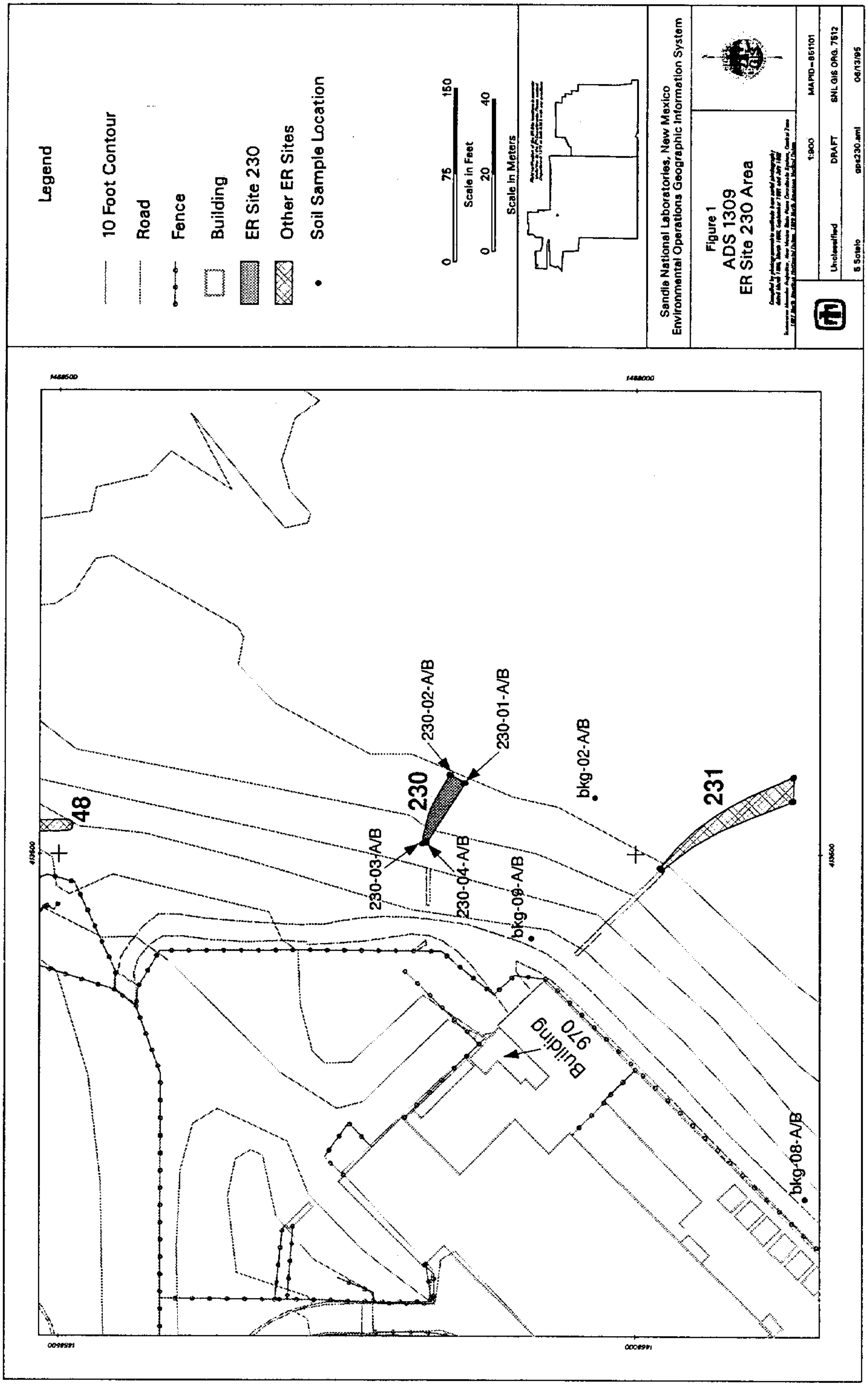

Figure 1. Storm Drain System Outfall Site 230.

Table 1. Site 230 - Results of Shallow Soil Sampling and Analysis

Sample Identifier	Analytical Method	Constituent	Concentration (mg/kg)	Qualifier(s)	Background (mg/kg)	Action Level (mg/kg)
230-01-B	VOCs (8240)	2-butanone	0.005	JB		
230-02-B	VOCs (8240)	2-butanone	0.004	JB		
230-03-B	VOCs (8240)	2-butanone	0.003	JB		
230-04-B	VOCs (8240)	2-butanone	0.003	JB		
230-04-B	SVOCs (8270)	Di-n-octyl phthalate	0.16	J		
230-03-B	TPH (8015)	TPH	110			
230-04-A	TPH (8015)	TPH	120			
230-04-B	TPH (8015)	TPH	110			
230-04-B	TAL Metals (6010)	Copper	18		13.6	1,450
230-01-A	TAL Metals (6010)	Zinc	93		79	20,000/11,300
230-01-B	TAL Metals (6010)	Zinc	110		79	20,000/11,300
230-02-A	TAL Metals (6010)	Zinc	140		79	20,000/11,300
230-02-B	TAL Metals (6010)	Zinc	120		79	20,000/11,300
230-03-A	TAL Metals (6010)	Zinc	110		79	20,000/11,300
230-03-B	TAL Metals (6010)	Zinc	88		79	20,000/11,300
230-04-A	TAL Metals (6010)	Zinc	100		79	20,000/11,300
230-04-B	TAL Metals (6010)	Zinc	82		79	20,000/11,300
230-01-A	Isotopic Uranium (HASL-300 4.5)	Uranium-235/236	0.23 pCi/g		0.33/ 0.168pCi/g	548 pCi/g

Notes

A "J" qualifier means detected at a concentration below the laboratory reporting limit.

A "B" qualifier means detected in the associated blank sample.

For copper and zinc, background is the 95 percent upper tolerance level for the local background data.

For uranium-235/236, the first background value is the maximum of six local background values; the second value is the base-wide background 95th percentile.

For zinc, the first action level is the proposed Subpart S action level.

The second action level for zinc and the action levels for copper and uranium-235/236 are calculated risk-based levels.

Table 2. Metal Risk Calculations for Site 230

Constituent	Concentration (mg/kg)	RfD(I) (mg/kg-day)	Individual HI	Source of RfD
Zinc	1.40E+02	3.00E-01	5.83E-03	IRIS
Copper	1.80E+01	3.70E-02	6.08E-03	Estimated from drinking water standard of 1.3 mg/l, 2 L/day ingestion rate, and 70 kg body weight.
Summed HI			1.19E-02	

Table 3. Radionuclide Risk Calculations for Site 230

Constituent	Activity (pCi/g)	DCF (mrem/pCi)	Individual Dose (mrem/year)	Source of DCF
Uranium-235/236	2.30E-01	2.50E-04	4.20E-03	Gilbert et al., 1989

APPENDIX A

Confirmatory Sampling and Analysis Plan

APPENDIX B

Analytical Results

APPENDIX C

Background Calculations for Metals and Radionuclides

APPENDIX D

Probability Plots, Local Background UTL Calculations, and Base-wide Background UTLs for Radionuclides

Appendix A
Confirmatory Sampling and Analysis Plan

SAMPLING AND ANALYSIS PLAN FOR ELEVEN SITES IN TIJERAS ARROYO OPERABLE UNIT SANDIA NATIONAL LABORATORIES/ NEW MEXICO

Sampling and Analysis Plan for Eleven Sites in Tijeras Arroyo Operable Unit

Introduction

The purpose of the sampling and analysis described in this plan is to determine the appropriate way to proceed toward closure of 11 (of the 17) sites in the Tijeras Arroyo Operable Unit. Based on the surface and shallow subsurface soil samples and analyses for the constituents of concern (COCs), one of three approaches will be pursued for each site:

1. A petition for "No Further Action" (NFA) will be produced for regulatory consideration;
2. A voluntary corrective measure (VCM) will be designed and implemented, hopefully followed by an NFA petition; or
3. The site assessment and eventual closure will follow the standard RFI/CMS path

Most of the sites covered by this Sampling and Analysis Plan (SAP) are outfalls from the storm water and sanitary sewer systems emanating from Sandia Technical Areas (TAs) I, II, and IV. The general sampling program for the outfalls will be to collect four samples at the head of the outfall, two samples of surface soil (0 to 6 inches deep) and two samples of shallow subsurface soil (18 to 36 inches deep) and four samples (two surface soil and two shallow subsurface soil) at the furthest extent of channel erosion and scour. The analytes for most of the samples are volatile organic compounds, semi-volatile organic compounds (BNAs), metals, chromium$^{+6,}$ for samples where chromium is found in a metals analysis, total petroleum hydrocarbon (TPH), explosives, Total Kjeldahl Nitrogen (TKN), nitrate/nitrite, and Gamma Spectroscopy for radionuclides, isotopic uranium, isotopic plutonium, tritium, and chlorodiphenyls (PCBs).

Sampling Procedures and Volumes

Surface soil samples will be collected with a stainless steel scoopula or trowel and placed in a stainless steel bowl. After at least 1000 ml[1] of soil has been collected, the soil will be thoroughly mixed in the bowl and transferred to two or three 500-ml sample bottles with a stainless steel scoopula. Sample bottles will be labeled accordingly and the appropriate sample information (sample depth, collection date and time, etc.) will be documented on the chain-of custody (COC) after each sample is collected. Samples will then be packaged and cooled to 4 degrees Celsius.

Shallow subsurface soil samples (18-36 inches) will be collected with a 2-inch (minimum) hand auger. A soil sample is collected by turning the auger clockwise and advancing it into the ground until the bucket at the end of the auger (last 6-8 inches) is full of soil or refusal occurs. Several runs with the auger is anticipated in order to obtain the appropriate volume. A hand shovel may also be used to bypass large rocks in order to continue with the auger. The auger is then extruded counter-clockwise from the ground and the soil is removed from the auger and placed in a stainless steel bowl. After 1,125[2] ml of soil has been collected, the soil will be mixed in the bowl and transferred to two or three 500-ml sample bottles and one 125-ml sample bottle with a stainless steel scoopula. Sample bottles will be labeled accordingly and the appropriate sample information will be documented on the COC after each sample is collected. Samples will then be packaged and cooled to 4 degrees Celsius.

Waste Generation and Equipment Decontamination

Decontamination of sampling equipment will be done between each sample. Decontamination will include thoroughly washing the inside and outside of the sampling equipment with a spray of ALCONOX™ or LIQUINOX™ and water; rinsing with distilled,

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[1]The sample volume varies between 1,000 and 1,500 ml depending on the analyses for the sample.

[2]The sample volume varies between 1,125 and 1,625 ml depending on the analyses for the sample.

deionized water; and drying before reusing. No soil waste will be generated. The soil removed from the hand-auger holes, while collecting samples at a depth of 18 to 36 inches, will be return to the hole. The sampling tools, which are scoopulas/trowels, hand-augers, and shovels, will be decontaminated with water and ALCONOX™ after each use. The decon leachate will be stored in capped 1-gallon containers. One or two containers will be used for each site and two to four containers will be used for the background samples. The containers will be labeled as "IDW" and the site number identified on each container. All the containers will be stored at Site 232, a central location. The leachate waste will be disposed according to the analytical results of the soil samples collected at the site.

Site Descriptions

The sites that will be sampled are

- Site 46, Old Acid Waste Line Outfall;
- Site 50, Old Centrifuge Site;
- Site 77, Oil Surface Impoundment;
- Site 227, Bldg. 904 outfall;
- Site 229, Storm Drain System Outfall;
- Site 230, Storm Drain System Outfall;
- Site 231, Storm Drain System Outfall;
- Site 232, Storm Drain System Outfall;
- Site 233, Storm Drain System Outfall;
- Site 234, Storm Drain System Outfall; and
- Site 235, Storm Drain System Outfall.

The site locations are shown in Figure 1. A description of the site history, conditions, previous investigations, and sampling plans are described in the following sections.

Site 46: Acid Waste Line Outfall

The Old Acid Waste Line carried wastes from several buildings in TA I. The waste line begins as a north-south trending, 750-feet long open trench in a grassy field northwest of Building 981-1 in TA IV. No pipe opening is visible at the "head" of the trench. As the trench crosses the field, it turns to the southeast and continues to a non-engineered spillway at the edge of Tijeras Arroyo. The spillway lies on a bank (40 to 50 feet of relief) composed of compacted alluvial sediment. Historical aerial photographs show vegetation, presumably supported by the discharge, growing southeast of the spillway to the active arroyo channel (about 200 feet distance from the spillway). The site is not restricted and is easily accessible.

During use, discharged effluent averaged an estimated 130,000 gallons per day. Use of the line has been discontinued. The line received wastes from plating, etching, and photo processing operations, and cooling tower "blow down". Acids and metals are target contaminants. Chromic acid and ferric chloride are mentioned specifically in the site history, and ferric chloride was found in the soils during a limited sampling event. Various radionuclides, possibly including tritium, uranium, and plutonium were used in TA I.

Building 863 was a source of discharge to the Acid Line. The information sheet for ER Site 98 (Building 863, TCA Photochemical Release: Silver Catch Boxes) indicates the presence of trichloromethane, silver, and photo-processing chemicals with an ammonia-like odor. The waste solution from the silver recovery unit reportedly was discharged to the Old Acid Waste Line, which is the only specific information about chemical discharges.

The site has been visually surveyed for surface indications of unexploded ordnance and high explosives (UXO/HE). No UXO/HE were found. Also, a surface radiation survey was conducted on the entire site. No surface radiation anomalies were detected.

The sampling program includes four samples collected at the "head" of the site outfall (by the fire extinguisher training area west of TA IV) and four samples collected by the spillway into the Tijeras Arroyo drainage (Figure 1). Every sample will be analyzed for tritium, metals, chromium^{+6} (if chromium is detected), TKN, and nitrate/nitrite. Half the samples will also be analyzed for semi-volatiles and cyanide. Additionally, all the subsurface samples will be analyzed for volatiles. The analytes are listed in Table 1. A "4" on the table indicates that ALL the samples will be analyzed
for that specific analyte whereas a "2" on the table indicates half the samples will have additional analyses for the analyte listed.

Site 50: Old Centrifuge
Site 50, Old Centrifuge, was an outdoor, rocket propelled centrifuge that was used in the early 1950s to test units under G forces. The facility is located east of the TA II fence in a slight depression on top the escarpment northwest of Tijeras Arroyo. The concrete centrifuge pad has a diameter of 80 to 90 feet. The site has a 7-foot high wooden retaining wall on the north, east, and south sides. The west side is open. The centrifuge arm assembly, which has a 20-foot radius, is sitting outside the wall to the north and appears to be intact. Control wiring to the center axis of the centrifuge was suspended from a cable between two telephone poles on the north and south side of the pad. The control wiring went to a bunker located to the southwest over the escarpment. The bunker had a electrical transformer containing PCB. The electrical transformer has been removed. The pad was not stained and no spills or leaks were reported.

The centrifuge was rocket driven by two T40 6-KS-3000 or two Deacon 3.5DS-5700 solid rocket motors. The combustion byproducts produced by these rocket motors were carbon dioxide, carbon monoxide, water, hydrochloric acid, aluminum oxide, and possibly barium oxide. No other HE is known or suspected at the site. The rocket orientation would expel combustion byproducts towards the retaining wall and the opening to the west. The rocket propellant would be consumed in the rocket motor case. Under normal operating conditions, no unburned propellant would be released.

In 1987, a reconnaissance investigation at five potential contaminated sites, including the Old Centrifuge Site, was conducted by the ER Project. Samples were analyzed for uranium, TNT, HSL inorganics, TCLP constituents, and EP Toxicity constituents. Metals, including barium, were detected at concentrations well below regulatory action levels. Total uranium concentrations were typical of area background levels. TNT, pesticides, PCBs, herbicides, and semi-volatiles TCLP compounds were not detected.

Prior to sampling, the surface will be surveyed for radiation. If contamination exists, it is expected to be around the edge of the centrifuge pad at the surface, probably along the open west side. The constituents of concern are metals (specifically lead, beryllium, and barium), depleted uranium, and high explosives. Four surface samples and four subsurface samples will be collected. The sampling locations will be biased toward the west side of the site because that is the open side (Figure 1). All surface samples will be analyzed for all the COCs. One-half of the subsurface samples will be analyzed for uranium and high explosives. All four subsurface samples will be analyzed for metals.

Site 77: Oil Surface Impoundment
The Oil Surface Impoundment Site is outside the TA IV fence, southeast of Building 981-1. The surface impoundment, which was constructed in the 1970's, is used to catch waste water from accelerators. At the time of the RCRA facilities environmental survey, the impoundment was unlined. Since then the impoundment was drained. Soil samples were analyzed for PCBs and

solvents. Based on the analytical results, the impoundment was determined to be clean. Subsequently, the impoundment was lined with geotextile and is now regulated under Sandia's Surface Water Discharge Program.

This site will not require UXO/HE or radiation surface surveys. Minimal confirmation sampling and analysis is proposed to verify that the site is clean. Three surface and three shallow subsurface samples are proposed. The samples will be collected along the perimeter of the existing lined pond (Figure 1). All the samples will be analyzed for PCBs. The subsurface soil samples also will be analyzed for volatile organic compounds (Table 1).

Site 227: Bunker 904 Outfall
Site 227 is an inactive outfall from the septic system for Building 904 (ER Site 48) in TA II. The site starts where the discharge exits the septic tank piping system, approximately 100 feet northeast of the southernmost point of TA II. The extent of the area influenced by the discharge may include the bank of Tijeras Arroyo below the outfall and some area between the outfall and the main channel of Tijeras Arroyo. The site is along the eastern edge of ER Site 45.

Building 904, built in 1948, was used for weapons assembly, HE testing, photo processing, and various other testing. Sanitary wastes were discharged to a septic tank, and other wastes were discharged to the outfall.

Mineral oil is also being considered a potential soil contaminant at all outfalls along the Tijeras Arroyo due to a recent release (June 1994) of mineral oil at Outfall 232 and vague historical records.

Possible soil contaminants are explosives, radioactive materials from weapons processing, including tritium, uranium, and plutonium, solvents (acetone, methylene chloride, methyl ethyl ketone, carbon tetrachloride, toluene, xylene, hexane, alcohols), and inorganics (ammonium hydroxide, barium, cadmium, silver, chromium, titanium, cyanide).

Access to this site is along the TA II perimeter road. This site is within the TA II testing exclusion zone. The best days to sample are generally Friday, Saturday, and Sunday, when testing ceases. Bruce Berry (telephone 845-8018) must be contacted to gain permission and access to this site. Prior to sampling

1. tumbleweeds will be cleared from locations to be sampled and placed adjacent to the drainage;
2. these locations will be visually scanned for UXO/HE; and
3. these locations will be screened for surface radiation anomalies.

The proposed sampling program is to collect four surface soil samples and four shallow subsurface samples. Two surface and two subsurface samples will be collected at the outfall. The other two surface and two subsurface samples will be collected at the furthest visible channel erosion and scour (Figure 1). The analytes are listed in Table 1.

Sites 229 - 235: Storm Drain Systems Outfalls
These sites consist of the discharge areas at seven outfalls along the northern embankment of Tijeras Arroyo. The outfalls discharged industrial effluent and storm water from TAs I, II, and IV. Presently they only discharge storm water. The outfalls receive runoff from Site 96 (Storm Drain System) and other engineered drain systems within the three TAs. The sites are along approximately ¾ miles of the embankment.

The specific constituents in the industrial effluent at these sites are not known. The possible discharged contaminants include chromates, antifoulants, chromium, sodium hydroxide, hydrochloric acid, chromosulfuric acid, diesel, and other petroleum products. To cover this array of possible contaminants, soil samples will be analyzed for volatiles (subsurface samples only), semi-volatiles, metals and chromium^{+6}, if chromium is found in the metals analysis.

Mineral oil is also being considered a potential soil contaminant at all outfalls along the Tijeras Arroyo due to a recent release (June '94) of mineral oil at Outfall 232 and vague historical records. Therefore, soil samples will also be analyzed for TPH.

At Sites 229 through 234, prior to sampling

1. tumbleweeds will be cleared from locations to be sampled and placed adjacent to the drainage;
2. these locations will be visually scanned for UXO/HE; and
3. these locations will be screened for surface radiation anomalies.

Site 229 is due east of the footings of the old guard tower and the south "corner" of the TA II fence. It discharges near the top of the embankment through the center of ER Site 45. Access to this site is along the TA II perimeter road. This site is within the TA II testing exclusion zone. The best days to sample are generally Friday, Saturday, and Sunday, when testing ceases. Bruce Berry (telephone 845-8018) must be contacted to gain permission and access to this site. Because this site discharges from TA II, various radionuclides, possibly including tritium, uranium, and plutonium are of concern. Four surface soil and four subsurface soil samples will be collected at this site (Figure 1). The analytes are listed in Table 1.

Site 230 is west of Building 970 in TA IV. A drain pipe discharges into a bowl-shaped concrete structure adjacent to Building 970A. Flow from this structure is directed to a drain and flume located approximately 120 feet further west. The flume carries the flow to a discharge point slightly above the base of the arroyo embankment. Doug Bloomquist (845-7455) must be contacted to ensure that no laser testing is being performed in the area. Four surface soil and four subsurface soil samples will be collected at this site (Figure 1). The analytes are listed in Table 1.

Site 231 is west of Building 970 in TA IV. A drain pipe discharges to a concrete flume near the top of the embankment. The flume carries the flow to a discharge point near the base of the slope. Doug Bloomquist (845-7455) must be contacted to ensure that no laser testing is being performed in the area..Four surface soil and four subsurface soil samples will be collected at this site (Figure 1). The analytes are listed in Table 1.

Site 232 consists of two outfalls. One outfall is south of Building 970A, east of the lined lagoon. A drain pipe discharges to a concrete flume near the top of the embankment. The flume carries the flow to at discharge point near the bottom of hillside. On June 1, 1994, about 150 to 350 gallons of mineral oil was spilled into this outfall through the storm water drain by building 986. The day after the spill the site was screened for radiation and UXO/HE. No surface radiation anomalies or UXO/HE were found. Also, four surface soil and four subsurface soil samples were collected. The samples were sent to Quintera Laboratory in Denver for analysis for organics, metals, chromium^{+6}, and gamma spec. Other than TPH from the mineral, no contaminants were detected. A Voluntary Corrective Measure was conducted in July and August to remove soil contaminated with mineral oil above 100 mg/kg of TPH.

The second outfall in Site 232 also is south of Building 970A, west of lined lagoon, and approximately 120 feet east of the other Site 232 outfall. Discharge occurs from a concrete structure opening near base of embankment. Access to the site is along the road outside the south side of TA IV. Four surface soil and four subsurface soil samples will be collected at this drainage Figure 1). The analytes are listed in Table 1.

Site 233 is south-southwest of Building 986. Near the top of an escarpment, a small metal drain pipe discharges to an open drain which directs flow within another pipe before discharging near the base of the hillslope. Access to the site is along the road outside the south side of TA IV. Four surface soil and four subsurface soil samples will be collected at this site (Figure 1). The analytes are listed in Table 1.

Site 234 is southeast of Building 981I (Inflatable Building) and a lagoon impoundment (Site 77).

The site discharges into a steep-sided, deeply incised channel cut into the hillside. The drainage channel splits directly uphill of a tree. Access to the site is along the road outside the south side of TA IV. Both channels will be sampled. Six surface soil and six subsurface soil samples will be collected at this site (Figure 1). The analytes are listed in Table 1.

Site 235 is immediately downstream of a large concrete spillway on the northeast side of Pennsylvania and south of the Skeet Range, at the point where the road comes off the north bank of the arroyo and descends into the channel. The flow moves in a confined channel after dropping down the spillway. The site has been cleared for visible surface UXO/HE and screened for surface radiation with no anomalies detected. This channel is considerably larger than the other outfall sites. Six surface soil and six subsurface soil samples will be collected at this site (Figure 1). The analytes are listed in Table 1.

Background

Background soil concentrations for organic contaminants should be negligible. Background concentrations for total metals and radionuclides must be determined for comparison to concentrations found at the sites. Twelve locations have been identified to collect samples for background determination (Figure 1). At each of these sites, one sample will be collected at a depth of 0-6 inches and a second sample collected at 18-36 inches (Table 1).. In addition, the background study report prepared by International Technology Corporation (May 1994) will also be used to evaluate the data.

Quality Assurance

As shown in Table 1, quality assurance samples will include the following:

- Field "duplicates" on more than 10 percent of the samples. These samples will be collected adjacent to the original surface soil sample and in the same hole as the original subsurface soil sample;
- Field soil blanks for more than 10 percent of the VOC analyses. These sample will be obtained from Sample Management Office (SMO) and will contain no VOCs; and
- One rinsate blank. All rinsate will be composited in one container. A sample of the rinsate will be analyzed for all constituents. The disposal method for the rinsate will be determined by the analytical results on this sample.

Table 1. List of Analytes - Tijeras Arroyo - Outfall Sampling and Analysis Plan

Site	Site Name	Potential Contaminants	Surface Soils															Subsurface Soils															
			Number of Samples	BNAs (8270)	TAL Metals (6010/7000)	Cr^{+6}* (aqueous leaching)	Cyanide (acid digestion)	TPH (8015)	Explosives Res (8330)	TKN (acid digestion)	NO_3/NO_2 (353.2)	Gamma Spec (In-House) 600 901.1	Gamma Spec (Off-site) 600 901.1	PCBs (8080)	Tritium (600 906.0)	Isotopic Plutonium (600 7-79-081)	Isotopic Uranium (HASL-300 4.5)	Number of Samples	VOCs (8240)	BNAs (8270)	TAL Metals (6010/7000)	Cr^{+6}* (aqueous leaching)	Cyanide (acid digestion)	TPH (8015)	Explosives Res (8330)	TKN (acid digestion)	NO_3/NO_2 (353.2)	Gamma Spec (In-House) 600 901.1	Gamma Spec (Off-site) 600 901.1	PCBs (8080)	Tritium (600 906.0)	Isotopic Plutonium (600 7-79-081)	Isotopic Uranium (HASL-300 4.5)
46	Old Acid Waste Line Outfall (Tijeras Arroyo)	Ferric chloride, chromic acid and other acids, ammonia, photo processing chemicals and other unknown chemicals	4	2	4	4	2			4	4	4	2		4	2	2	4	4	2	4	4	2			4	4	4			4	2	2
50	Old Centrifuge Site (TA-2)	Rocket propellant and residues	4		4				4			2			2	1	2	4			4				2						1		1
77	Oil Surface Impoundment	Solvents and PCBs	4											4				4	4											4			
227	Bldg. 904 outfall (TA-2)	High explosives, radioactive materials, nitrate, toluene, methanol, other solvents, carbon tetrachloride, ammonium hydroxide, barium, cadmium, silver, chromium, titanium, cyanide	4	2	4	4	2	2	2	4	4	4	2		4	2	2	4	4	2	4	4	2	4	2	4	4	4			4	2	2
229	Storm Drain System Outfall	Chromates, antifoulants, chromium, sodium hydroxide, hydrochloric acid, chromosulfuric acid, diesel, other petroleum products	4	2	4	4		4				4	2		4	2	2	4	4	2	4	4		4				4			4	2	2
230	Storm Drain System Outfall	Chromates, antifoulants, chromium, sodium hydroxide, hydrochloric acid, chromosulfuric acid, diesel, other petroleum products	4	2	4	4		4				2			2	1	1	4	4	2	4	4		4				2					
231	Storm Drain System Outfall	Chromates, antifoulants, chromium, sodium hydroxide, hydrochloric acid, chromosulfuric acid, diesel, other petroleum products	4	2	4	4		4				2			2	1	1	4	4	2	4	4		4				2					
232	Storm Drain System Outfall	Chromates, antifoulants, chromium, sodium hydroxide, hydrochloric acid, chromosulfuric acid, diesel, other petroleum products	4	2	4	4		4				2			2	1	1	4	4	2	4	4		4				2					
233	Storm Drain System Outfall	Chromates, antifoulants, chromium, sodium hydroxide, hydrochloric acid, chromosulfuric acid, diesel, other petroleum products	4	2	4	4		4				2			2	1	1	4	4	2	4	4		4				2					
234	Storm Drain System Outfall	Chromates, antifoulants, chromium, sodium hydroxide, hydrochloric acid, chromosulfuric acid, diesel, other petroleum products	6	3	6	6		6				2			2	1	1	6	6	3	6	6		6				2					
235	Storm Drain System Outfall	Chromates, antifoulants, chromium, sodium hydroxide, hydrochloric acid, chromosulfuric acid, diesel, other petroleum products	4	2	4	4		4				2			2	1	1	4	4	2	4	4		4				2					
Na	Background		12		12							12			3	3	3	12			12							12			3	3	3
QA	Duplicates	Na		2	5	4	1	4	1	1	1		1	1			2		5	2	5	4	1	4	1	1	1			1			1
QA	Field Soil Blank	Na																	5														
QA	Rinsate	Na		1	1	1	1	1	1	1	1	1	1	1	1	1	1		1		1												
	Totals		**58**	**22**	**60**	**43**	**6**	**37**	**8**	**10**	**10**	**39**	**8**	**6**	**30**	**17**	**20**	**58**	**53**	**21**	**60**	**42**	**5**	**38**	**5**	**9**	**9**	**36**		**5**	**16**	**9**	**11**
Totals - Surface Plus Subsurface			**116**	**43**	**120**	**85**	**11**	**75**	**13**	**19**	**19**	**75**	**8**	**11**	**46**	**26**	**31**		**53**														

* Analyze for Cr^{+6} only if Cr is detected in metals analysis

Appendix B
Analytical Results

ACRONYMS FOR ANALYTICAL DATA

Organic/metals data for soil = mg/kg
Radionuclides data for soil = pCi/g

ND = Not detected

NS = Not significant

MDA = Maximum Detectable Activity

J = Detected at a concentration below the laboratory reporting limit

B = Detected in the associated blank sample

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Site 230 Soil Results

Sample Identifier	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury
230-01-A	3800	7.2	7	200	0.3	1.7	37000	5.6	4.2	7.1	10000	8.2	3200	170	ND
230-01-B	4100	7.8	2	260	0.3	1.2	55000	4.7	3.4	6.1	7400	6	3400	160	ND
230-02-A	3600	6.7	2	260	0.3	1	29000	3.5	3.2	5.9	6300	5.6	2800	170	ND
230-02-B	1700	3.8	1	200	ND	0.8	21000	2.4	ND	6	4500	3.7	1500	120	ND
230-03-A	2300	4.8	2	200	ND	0.6	29000	2.6	ND	6.5	3700	4	2100	120	ND
230-03-B	2200	4	2	180	ND	0.8	28000	4.5	ND	7.8	4300	3.9	1900	100	ND
230-04-A	1900	3.9	2	180	ND	0.6	26000	2.2	ND	5.5	3200	5.3	1700	97	ND
230-04-B	1500	3.3	2	130	ND	0.6	30000	2.3	ND	18	3500	4.2	1500	110	ND

Sample Identifier	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc	Cr^{+6*}	Tritium	Plutonium 239/240	Plutonium 238	Uranium-238	Uranium-235/236	Uranium-234
230-01-A	5.8	1500	ND	ND	470	ND	21	93	ND	<0.008	<0.005	<0.008	0.57	0.2	0.8
230-01-B	6.3	1300	ND	ND	640	ND	14	110	ND						
230-02-A	6.3	1200	ND	ND	810	ND	11	140	ND						
230-02-B	3	650	ND	ND	690	ND	9.6	120	ND						
230-03-A	3.1	840	ND	ND	530	ND	8.8	110	ND						
230-03-B	2.9	740	ND	ND	440	ND	9.1	88	ND						
230-04-A	2.6	610	ND	ND	540	ND	7.4	100	ND	<0.018					
230-04-B	3	530	ND	ND	360	ND	9.1	82	ND						

Concentrations in mg/kg
Activities in pCi/g
Sample Identifier XX-XX-A - surface soil samples
Sample Identifier XX-XX-B - subsurface soil samples

Quality Assurance Results for Organic Constituents

Sample Identifier	Sample Type	2-Butanone	2-Hexanone	4-Methyl-2-pentanone	Acetone	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Chrysene	Di-n-octyl phthalate	Fluoranthene	Methylene Chloride	Phenanthrene	Pyrene	Styrene	total-Xylenes	TPH
227-01-A	original										0.066 J		0.055 J	0.040 J			
227-01-A	duplicate										0.038 J		0.051 J				
227-01-B	original	0.007 J		0.001 J													
227-01-B	duplicate	0.006 J			0.006 J												
227-04-B	original	0.004 J															
227-04-B	duplicate	0.005 J															
229-01-A	original					0.071 J	0.050 J	0.16 J	0.11 J		0.23 J		0.17 J	0.19 J			ND
229-01-A	duplicate					0.006 J	0.092 J	0.16 J	0.12 J		0.20 J		0.18 J	0.28 J			81
229-02-B	original	0.006 J															
229-02-B	duplicate	0.006 J															
229-03-B	original	0.006 J															
229-03-B	duplicate	0.006 J															
230-04-B	original	0.003 JB								0.16 J							
230-04-B	duplicate																
235-02-B	original	0.006 JB															
235-02-B	duplicate	0.004 JB															
Site 227	trip blank	0.010 B	0.003 J	0.002 J	0.019												
Site 229	trip blank	0.009 JB			0.015												
Site 230	trip blank	0.004 JB										0.003 J					
Site 232	trip blank	0.007 JB															
Site 234	trip blank	0.007 JB			0.015										0.001 J		
Site 235	rinsate	0.005 JB			0.010											0.001 J	ND

Quality Assurance Results for Inorganic and Radiological Constituents

Sample Identifier	Sample Type	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Manganese	Mercury	Nickel	Vanadium	Zinc
227-02-A	original	5800	9.3	5.9	180	ND	2.1	6.6	4.1	7.8	13000	7.5	160	ND	5.4	27	51
227-02-A	duplicate	6500	11	1.4	150	0.25	2.5	6.4	4.1	13	14000	9.1	170	ND	5.9	28	51
227-03-B	original	5100	8.8	0.92	140	ND	2.1	5.9	4.5	11	13000	7.5	200	ND	5.4	25	48
227-03-B	duplicate	6400	9.9	5.6	140	0.25	2.9	7.4	4.6	10	16000	8.9	230	ND	5.9	33	50
229-04-A	original	8100	13	5.7	150	0.32	2.3	8.0	4.2	7.9	13000	12	210	ND	6.3	24	55
229-04-A	duplicate	7700	12	1.5	140	0.30	2.2	8.0	4.2	7.7	12000	11	190	ND	6.2	24	52
230-04-B	original	1500	3.3	1.6	130	ND	0.61	2.3	ND	18	3500	4.2	110	ND	3.0	9.1	82
230-04-B	duplicate	2400	4.9	1.7	140	ND	0.68	3.1	2.5	15	4500	4.1	120	ND	3.4	9.7	71
235-01-A	original	3600	6.2	5.1	150	ND	2.7	6.0	8.4	6.6	20000	7.6	210	ND	4.5	36	66
235-01-A	duplicate	3000	5.3	1.3	160	ND	1.6	4.2	5.7	6.5	12000	9.4	180	ND	4.4	22	66
50-01-B	original	3100	6.5	2.1	110	0.25	1.3	4.1	3.9	6.2	7600	6.6	130	ND	4.5	17	18
50-01-B	duplicate	3900	7.5	2.0	110	0.26	1.3	4.3	4.0	5.7	8800	5.9	150	ND	4.2	18	21
50-02-A	original	5800	12	4.2	220	0.38	1.6	5.2	4.3	12	6700	25	210	ND	7.1	11	69
50-02-A	duplicate	7000	14	6.4	280	0.55	2.2	8.3	6.1	17	9000	35	290	0.04	9.4	18	61
Bkg-05-A	original	6400	13	5.7	210	0.53	1.8	6.1	6.6	14	10000	16	330	ND	8.9	22	37
Bkg-05-A	duplicate	5900	12	7.6	190	0.50	1.7	6.0	6.3	14	10000	16	320	ND	8.7	24	36
Site 235	rinsate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Sample Identifier	Sample Type	TKN	NO_3/NO_2	Potassium 40	Lead 212	Lead 214	Plutonium 239/240	Uranium 238	Uranium 235/236	Uranium 234
227-02-A	original	400	2.7							
227-02-A	duplicate	320	9.3							
227-03-A	original						0.004	0.4	0.15	0.61
227-03-A	duplicate							0.67	0.023	0.67
227-03-B	original							0.72	0.11	0.72
227-03-B	original	220	ND							
227-03-B	duplicate			27.8	0.71	0.7				
227-03-B	duplicate	190	1.4							
229-01-A	original						0.007	0.45	0.17	0.67
229-01-A	duplicate							0.73	0.034	0.6
229-03-B	original							0.45	0.058	0.45
229-03-B	duplicate							0.99	0.06	1

Notes on Quality Assurance Data

Explosive residues were not detected in Site 50 duplicate sample

Hexavalent chromium was not detected in five duplicates and one decon rinsate

Cyanide was not detected in two duplicates and one decon rinsate

PCBs were not detected in one Site 77 duplicate sample

Tritium and Plutonium-238 were not detected in four duplicate samples

Selenium, silver, and thallium were not detected in any quality assurance samples

Appendix C
Background Calculations for Metals and Radionuclides

Appendix C. Background Calculations for Metals and Radionuclides

To evaluate metals data, 24 background samples were collected for metals analyses.[4] Distribution analyses was performed first by constructing histograms. The histograms indicated a parametric distribution. Outliers were screened in a two-step process as described in the base wide background report (IT 1994). The first step is to perform an "a priori" screening for very high values relative to the rest of the data set. This is qualitatively performed by visually examining a column of sorted values. Maximum values that are a factor of 3 or 4 times higher than their nearest neighbor are removed from the data set during this step. None of the anomalous values were deleted by the "a priori" process.

The second step, from EPA, 1989, determines whether an observation that appears extreme fits the data distribution. A statistical parameter, T_n is calculated:

$$T_n = (X_n - X_a)/S$$

where:

X_n = questionable observation;

X_a = sample arithmetic mean; and

S = sample standard deviation

T_n is compared to a table of one-sided critical values for the appropriate significance level (upper 5 percent) and sample size from a table provided in EPA 1989. Extreme concentrations for barium, calcium, chromium, copper and nickel were identified as outliers and were excluded from the data set. These anomalous values may have resulted from laboratory or sampling error.

Probability plots were then replotted to determine whether the data fit normal or lognormal populations. These plots are shown in Appendix D. The UTL[5] was calculated for data sets that fit a normal or lognormal distribution. Data sets are provided in Appendix D. As recommended by EPA, a tolerance coefficient value of 95 percent was used (EPA 1989). Most metals background data fit lognormal distributions. Iron and zinc data fit normal distributions. UTLs were not calculated for mercury, selenium, and silver because mercury and selenium were not detected and silver was detected only once in the 24 background samples. The beryllium background data did not fit a normal or lognormal distribution. The maximum value in a data set is commonly taken as the UTL in a non-parametric setting (Guttman, 1970). The maximum background beryllium concentration was 0.53 mg/kg.

Base-wide background UTLs for radionuclides were established by International Technology (IT) Corporation to compare and evaluate radionuclide data (IT, 1994). A table is provided in Appendix

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[2]These data are referred to as local background data. The data collected throughout Kirtland Air Force Base (KAFB), with most of the data collected within SNL/NM technical areas, are called base-wide background data (IT 1994).

[3]$UTL = x + K \cdot S$, where:

UTL = Upper tolerance limit;

x = Sample arithmetic mean (for normal distribution), sample geometric mean (for lognormal distribution);

S = Sample standard deviation; and

K = One-sided normal tolerance factor (95 percent for these evaluations).

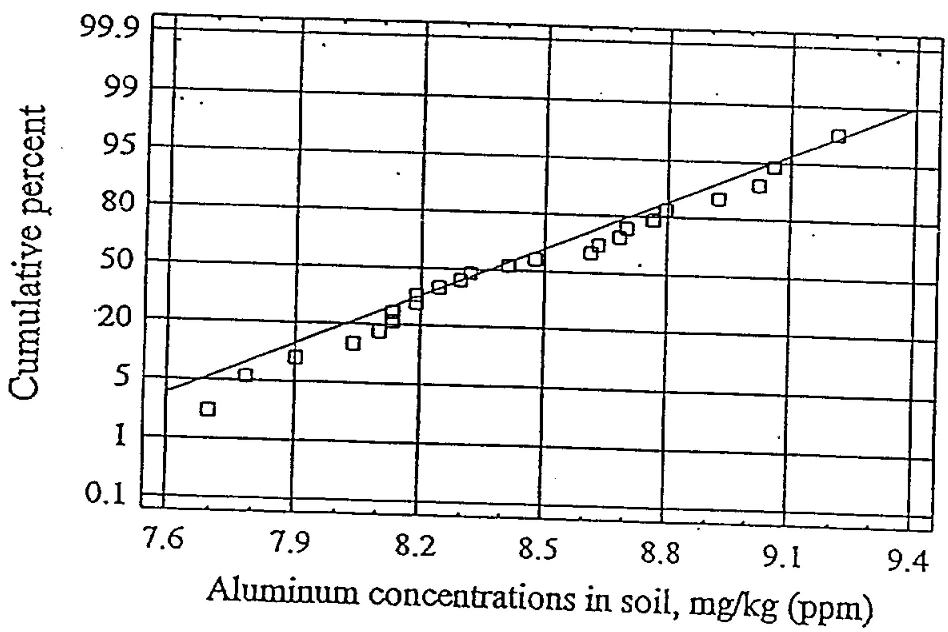
D with radionuclide background data and the corresponding UTLs. The maximum activity from the six local background samples for isotopic plutonium and isotopic uranium was used as an additional method to evaluate the data. Also, in-house gamma spectroscopy was performed on all 24 background samples and indicated low levels of radioactivity but no significant contamination.

Appendix D
Probability Plots, Local Background UTL Calculations, and Base-Wide Background UTLs for Radionuclides

Su Statistics for log(Aluminum)

Cou = 24
verage = 8.42942
edian = 8.36529
ode =
eometric mean = 8.41976
ariance = 0.170246
tandard deviation = 0.412609
tandard error = 0.0842235
inimum = 7.69621
aximum = 9.21034
ange = 1.51413
ower quartile = 8.13153
pper quartile = 8.73178
nterquartile range = 0.600253
kewness = 0.132255
tnd. skewness = 0.26451
urtosis = -0.792361
tnd. kurtosis = -0.792361
oeff. of variation = 4.89487
um = 202.306

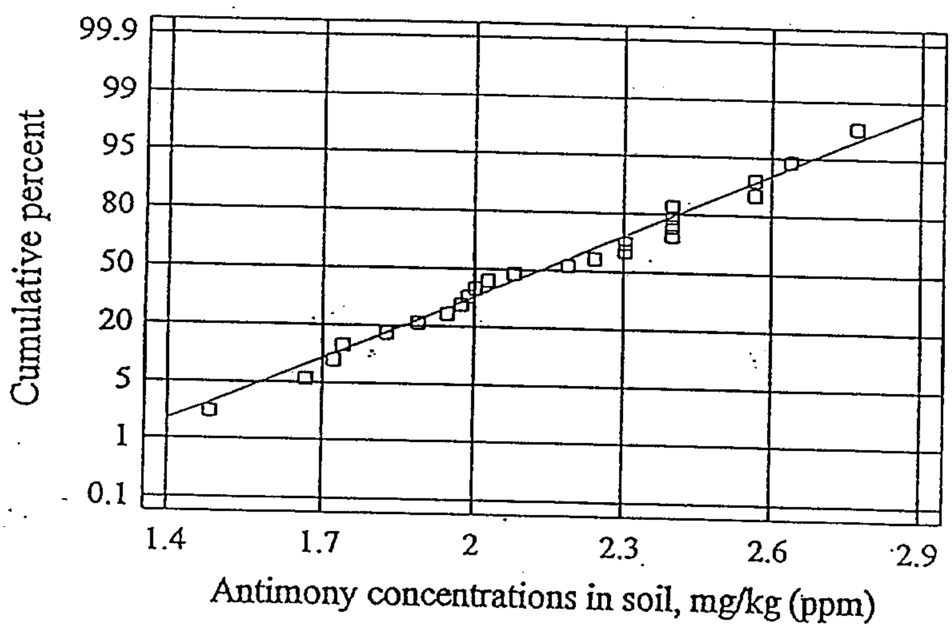
Lognormal Probability Plot for Aluminum



Summary Statistics for log(Antimony)

Count = 24
Average = 2.14609
Median = 2.13275
Mode = 2.3979
Geometric mean = 2.12004
Variance = 0.113831
Standard deviation = 0.337389
Standard error = 0.0688692
Minimum = 1.4816
Maximum = 2.77259
Range = 1.29098
Lower quartile = 1.91649
Upper quartile = 2.3979
Interquartile range = 0.481405
Skewness = -0.040772
Stnd. skewness = -0.0815441
Kurtosis = -0.744171
Stnd. kurtosis = -0.744171
Coeff. of variation = 15.7211
Sum = 51.5062

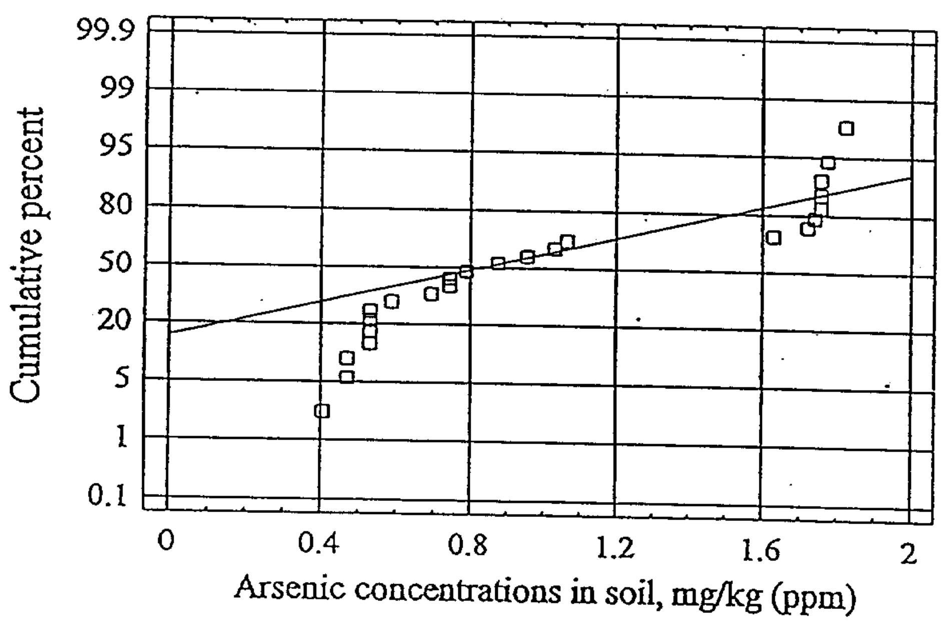
Lognormal Probability Plot for Antimony



mmary Statistics for log(Arsenic)

= 24
erage = 1.038
dian = 0.831963
de =
ometric mean = 0.908119
riance = 0.291153
andard deviation = 0.539586
andard error = 0.110143
nimum = 0.405465
ximum = 1.82455
nge = 1.41908
wer quartile = 0.530628
per quartile = 1.73162
erquartile range = 1.20099
wness = 0.463036
d. skewness = 0.926071
tosis = -1.58507
d. kurtosis = -1.58507
ff. of variation = 51.983
= 24.9121

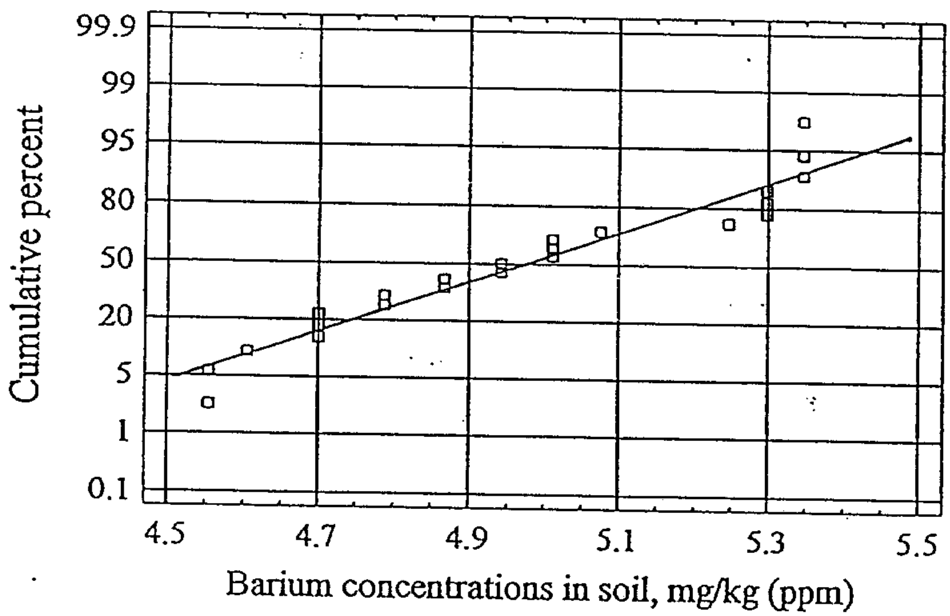
Lognormal Probability Plot for Arsenic



macy Statistics for log(Barium)

```
nt = 23
rage = 4.96940
ian = 4.94164
e = 5.34711
metric mean = 4.96236
iance = 0.0740602
ndard deviation = 0.27214
ndard error = 0.0567451
.mum = 4.55388
.mum = 5.34711
ge = 0.793231
r quartile = 4.70048
r quartile = 5.29832
rquartile range = 0.597837
ness = 0.0653415
. skewness = 0.127931
osis = -1.30542
. kurtosis = -1.27794
f. of variation = 5.47622
= 114.298
```

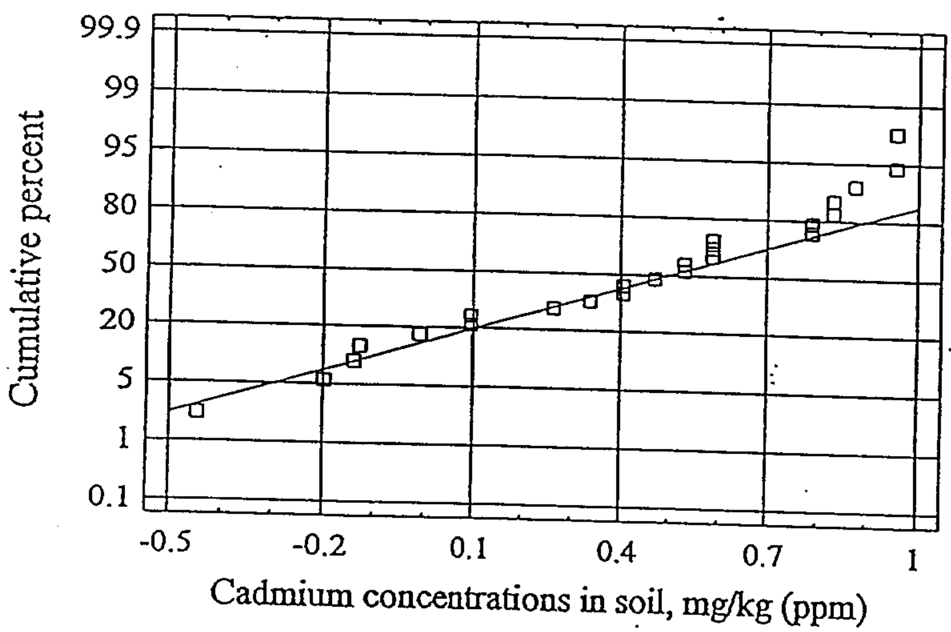
Lognormal Probability Plot for Barium



Summary Statistics for log(Cadmium)

Count = 24
Average = 0.416764
Median = 0.500316
Mode =
Geometric mean =
Variance = 0.159937
Standard deviation = 0.399922
Standard error = 0.0816337
Minimum = -0.446287
Maximum = 0.955511
Range = 1.4018
Lower quartile = 0.0953102
Upper quartile = 0.788457
Interquartile range = 0.693147
Skewness = -0.506707
Stnd. skewness = -1.01341
Kurtosis = -0.674504
Stnd. kurtosis = -0.674504
Coeff. of variation = 95.9587
Sum = 10.0023

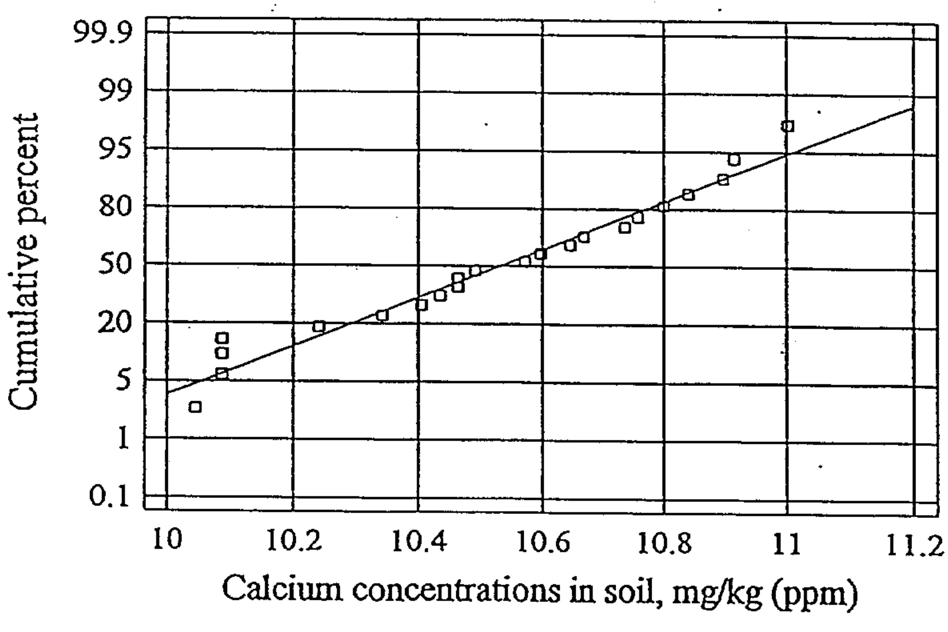
Lognormal Probability Plot for Cadmium



ummary Statistics for log(Calcium)

ount = 23
verage = 10.5579
edian = 10.5713
ode = 10.0058
eometric mean = 10.5532
ariance = 0.10513
tandard deviation = 0.324237
tandard error = 0.0676081
inimum = 10.0432
aximum = 11.2645
ange = 1.22121
ower quartile = 10.3417
pper quartile = 10.7996
nterquartile range = 0.457833
kewness = 0.109797
tnd. skewness = 0.214971
urtosis = -0.415646
tnd. kurtosis = -0.406895
oeff. of variation = 3.07103
um = 242.832

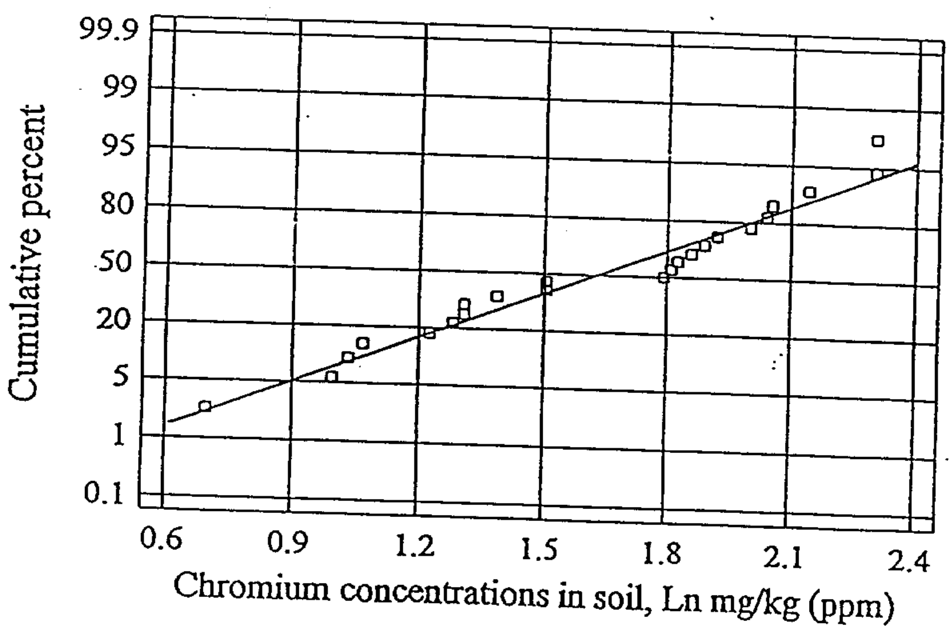
Lognormal Probability Plot for Calcium



u y Statistics for log(Chromium)

o = 23
verage = 1.61841
edian = 1.79176
ode =
eometric mean = 1.55042
ariance = 0.204195
tandard deviation = 0.451879
tandard error = 0.0942233
inimum = 0.693147
aximum = 2.30259
ange = 1.60944
wer quartile = 1.28093
per quartile = 2.00148
terquartile range = 0.720546
ewness = -0.274151
nd. skewness = -0.536757
rtosis = -0.905395
nd. kurtosis = -0.886332
eff. of variation = 27.9211
m = 37.2235

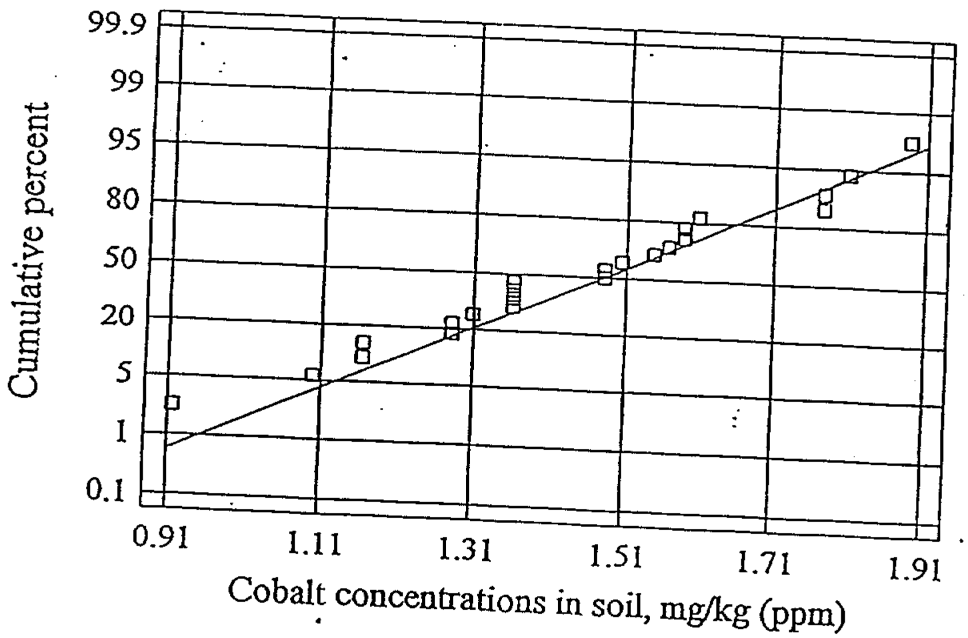
Lognormal Probability Plot for Chromium



ummary Statistics for log(Cobalt)

ount = 24
verage = 1.29969
edian = 1.42129
ode =
eometric mean =
iriance = 0.574775
tandard deviation = 0.758139
tandard error = 0.154754
nimum = -2.07944
iximum = 1.88707
nge = 3.96651
wer quartile = 1.28093
per quartile = 1.58924
terquartile range = 0.308301
ewness = -4.13299
nd. skewness = -8.26598
rtosis = 18.9091
nd. kurtosis = 18.9091
eff. of variation = 58.3324
n = 31.1925

Lognormal Probability Plot for Cobalt

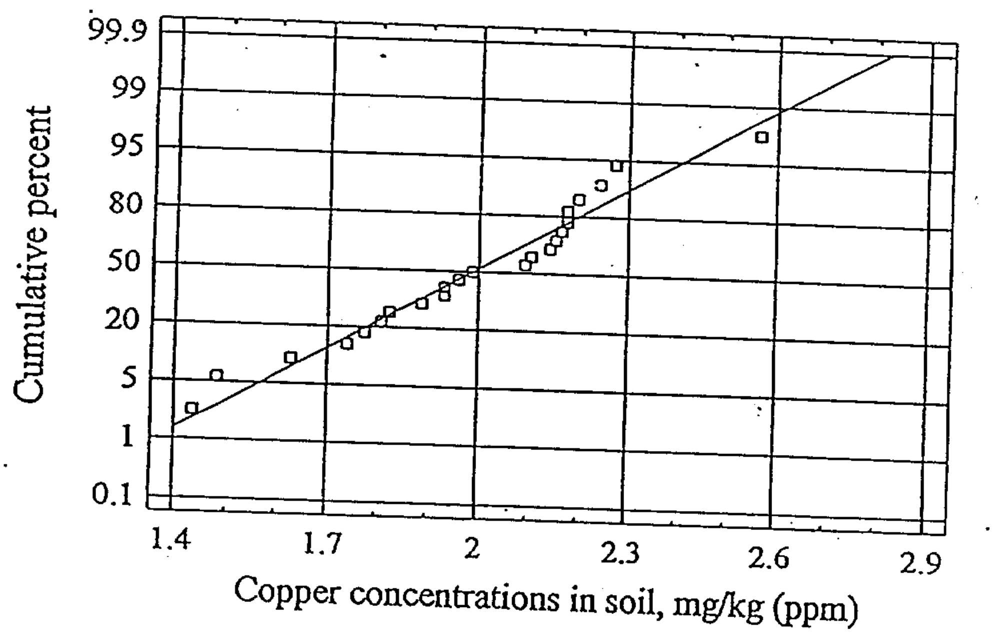


35

Su ary Statistics for log(Copper)

C = 23
Average = 1.98556
Median = 1.98787
Mode =
Geometric mean = 1.96762
Variance = 0.0713494
Standard deviation = 0.267113
Standard error = 0.0556969
Minimum = 1.43508
Maximum = 2.56495
Range = 1.12986
Lower quartile = 1.80829
Upper quartile = 2.17475
nterquartile range = 0.366463
kewness = -0.263077
tnd. skewness = -0.515077
urtosis = 0.18883
tnd. kurtosis = 0.184854
oeff. of variation = 13.4528
um = 45.6679

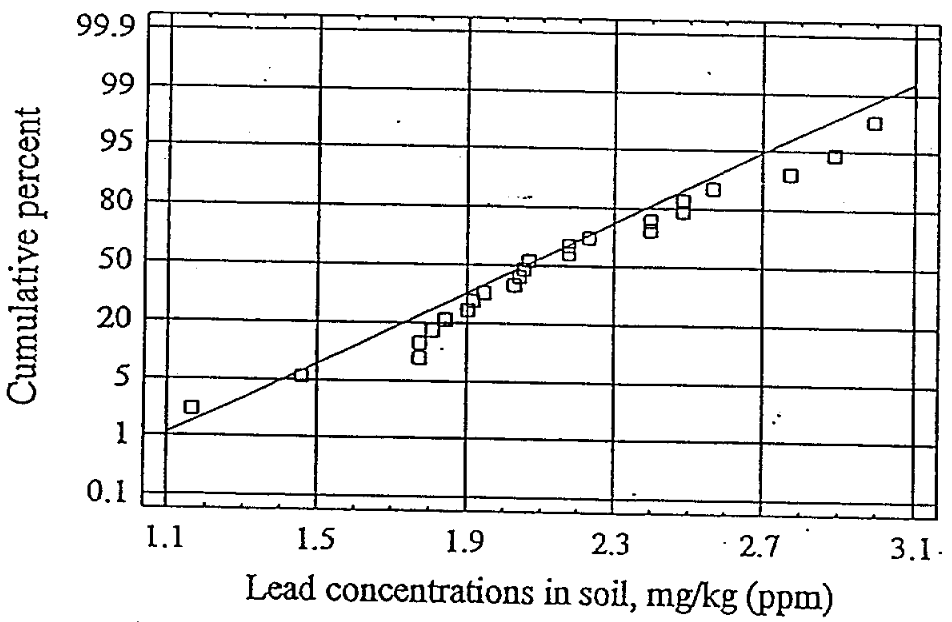
Lognormal Probability Plot for Copper



ummary Statistics for log(Lead)

ount = 24
verage = 2.13936
edian = 2.06049
ode =
eometric mean = 2.09509
ariance = 0.187882
tandard deviation = 0.433454
andard error = 0.0884784
inimum = 1.16315
aximum = 2.99573
ange = 1.83258
ower quartile = 1.87133
pper quartile = 2.4414
nterquartile range = 0.570072
ewness = 0.0350174
nd. skewness = 0.0700348
rtosis = 0.200156
nd. kurtosis = 0.200156
eff. of variation = 20.261
m = 51.3446

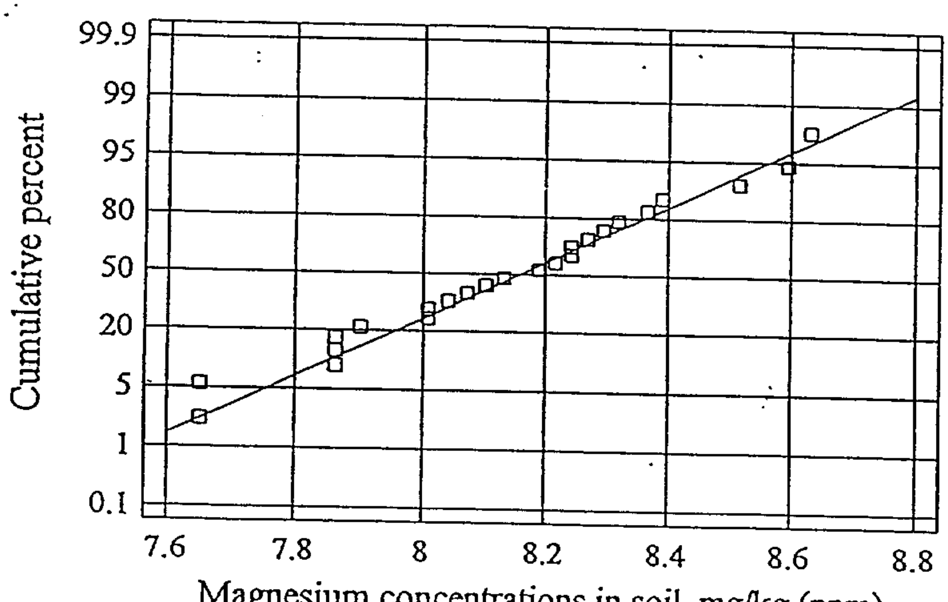
Lognormal Probability Plot for Lead



mm ry Statistics for log(Magnesium)

c = 24
erage = 8.14232
dian = 8.16011
de =
ometric mean = 8.13815
riance = 0.0706013
andard deviation = 0.265709
andard error = 0.0542376
nimum = 7.64969
ximum = 8.63052
nge = 0.980829
wer quartile = 7.95369
per quartile = 8.3064
terquartile range = 0.352709
wness = -0.0600481
d. skewness = -0.120096
tosis = -0.414246
d. kurtosis = -0.414246
ff. of variation = 3.26331
= 195.416

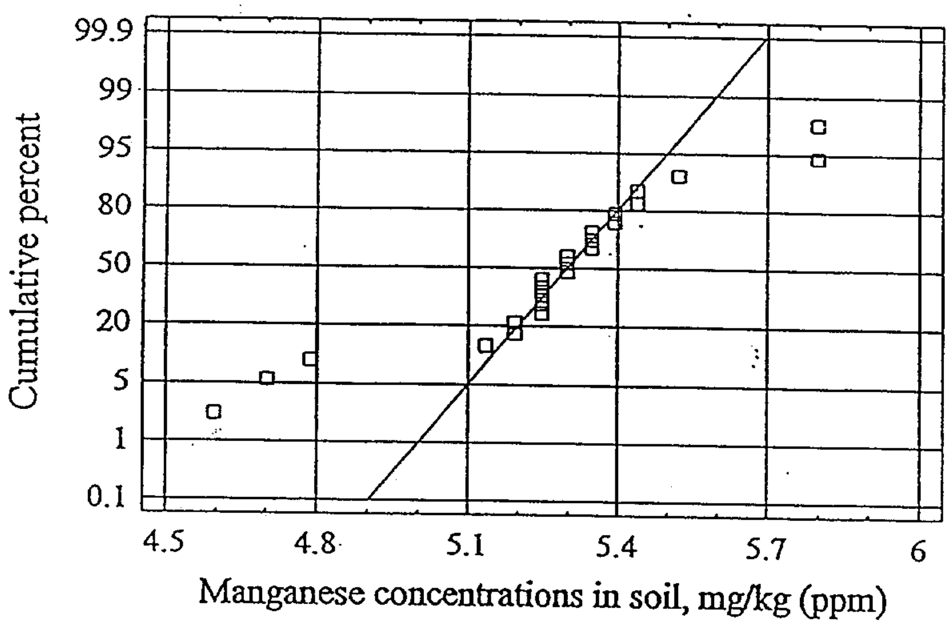
Lognormal Probability Plot for Magnesium



ımmary Statistics for log(Manganese)

ount = 24
erage = 5.2733
dian = 5.29832
de =
ometric mean = 5.2661
riance = 0.0771874
andard deviation = 0.277826
andard error = 0.056711
nimum = 4.59512
ximum = 5.79909
nge = 1.20397
wer quartile = 5.21999
per quartile = 5.39363
terquartile range = 0.173637
ewness = -0.660387
nd. skewness = -1.32077
rtosis = 1.62566
nd. kurtosis = 1.62566
eff. of variation = 5.26854
n = 126.559

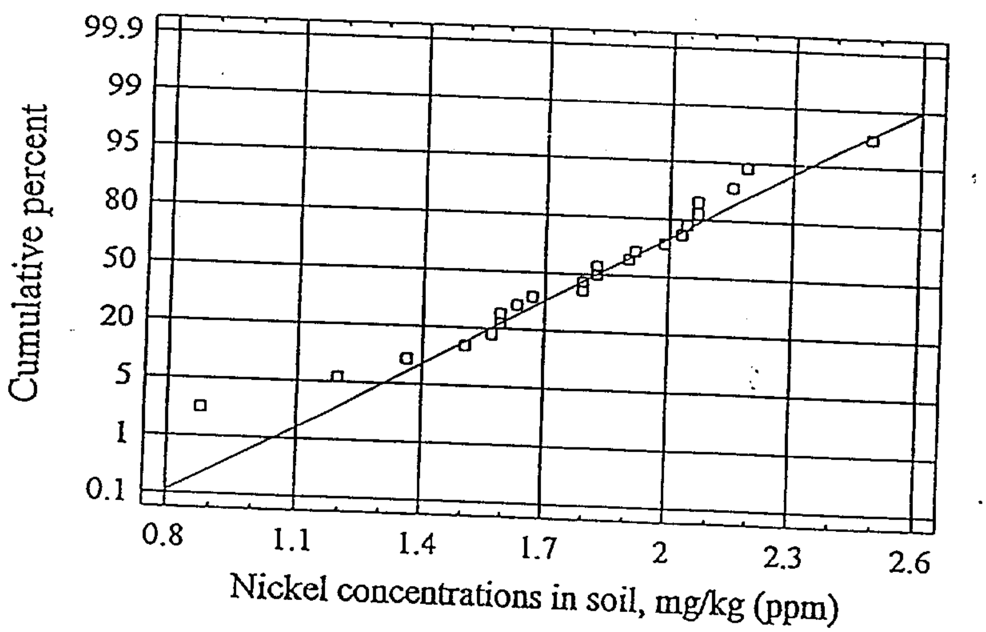
Lognormal Probability Plot for Manganese



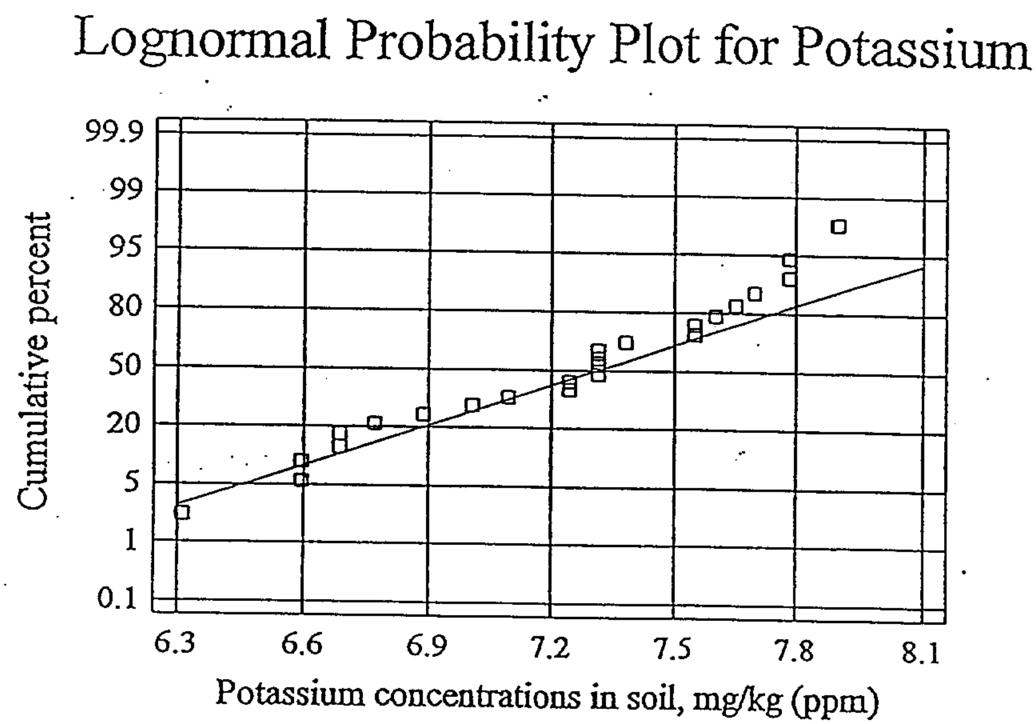
Summary Statistics for log(Nickel)

Count = 23
Average = 1.78451
Median = 1.82455
Mode =
Geometric mean = 1.74596
Variance = 0.1246
Standard deviation = 0.352987
Standard error = 0.0736029
Minimum = 0.875469
Maximum = 2.48491
Range = 1.60944
Lower quartile = 1.58924
Upper quartile = 2.04122
Interquartile range = 0.451985
Skewness = -0.609856
Stnd. skewness = -1.19403
Kurtosis = 0.992502
Stnd. kurtosis = 0.971605
Coeff. of variation = 19.7806
Sum = 41.0438

Lognormal Probability Plot for Nickel



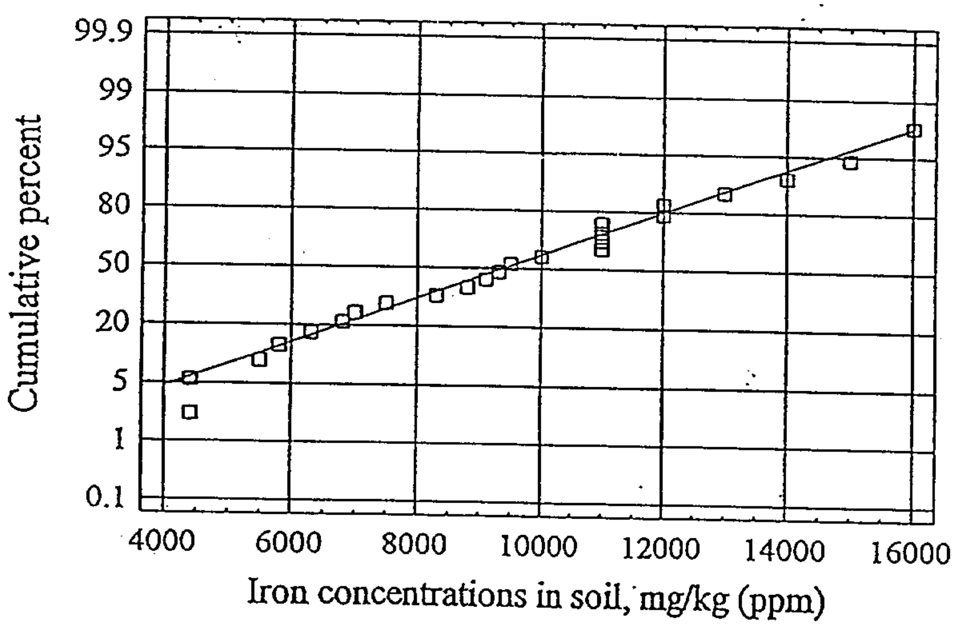
```
ımmary Statistics for log(Potassium)

ount = 24
erage = 7.21862
dian = 7.31322
de = 7.31322
ometric mean = 7.20542
riance = 0.195599
andard deviation = 0.442265
andard error = 0.0902771
nimum = 6.30992
ximum = 7.90101
nge = 1.59109
wer quartile = 6.82802
per quartile = 7.57526
terquartile range = 0.747233
ewness = -0.373735
nd. skewness = -0.74747
rtosis = -0.83864
nd. kurtosis = -0.83864
eff. of variation = 6.12673
n = 173.247
```



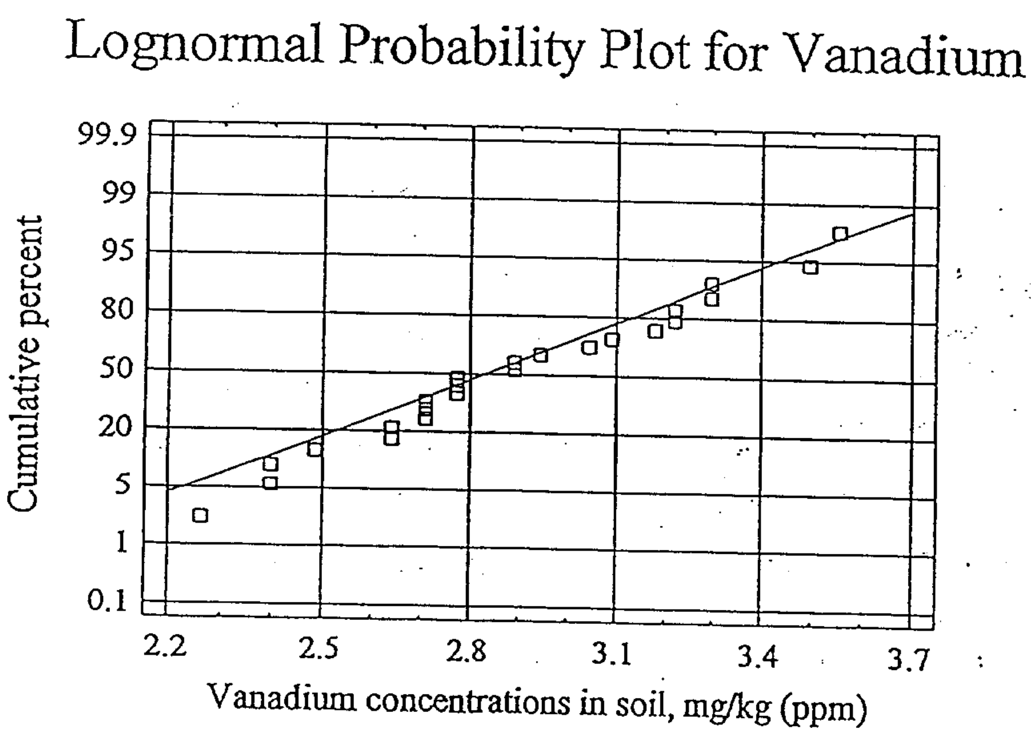
ummary Statistics for Iron

= 24
ge = 9529.17
edian = 9400.0
ode = 11000.0
eometric mean = 8977.5
ariance = 1.0363E7
tandard deviation = 3219.17
tandard error = 657.109
inimum = 4400.0
aximum = 16000.0
ange = 11600.0
ower quartile = 6900.0
oper quartile = 11500.0
iterquartile range = 4600.0
kewness = 0.20025
nd. skewness = 0.400499
irtosis = -0.620589
nd. kurtosis = -0.620589
eff. of variation = 33.7822
m = 228700.0

Normal Probability Plot for Iron



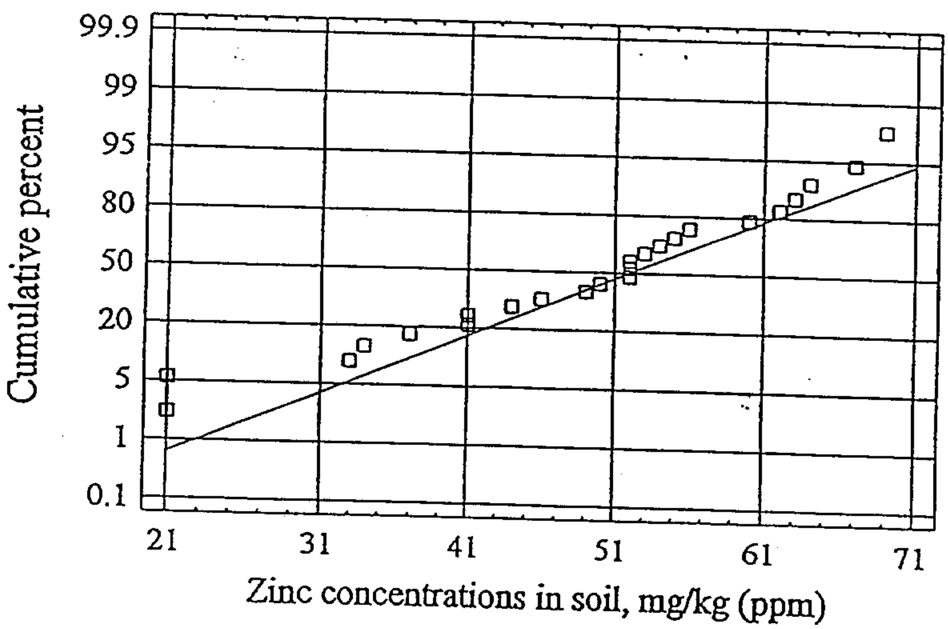
```
mary Statistics for log(Vanadium)

int = 24
rage = 2.89094
lian = 2.83148
le =
metric mean = 2.87064
iance = 0.122444
ndard deviation = 0.34992
ndard error = 0.0714271
imum = 2.26176
imum = 3.55535
ge = 1.29358
er quartile = 2.67355
er quartile = 3.19846
erquartile range = 0.524911
wness = 0.158415
d. skewness = 0.316831
tosis = -0.688491
d. kurtosis = -0.688491
ff. of variation = 12.104
 = 69.3826
```



Summary Statistics for Zinc

Count = 24
Average = 49.0
Median = 52.0
Mode = 52.0
Geometric mean = 46.9434
Variance = 171.478
Standard deviation = 13.095
Standard error = 2.673
Minimum = 21.0
Maximum = 69.0
Range = 48.0
Lower quartile = 41.0
Upper quartile = 58.0
Interquartile range = 17.0
Skewness = -0.633044
Stnd. skewness = -1.26609
Kurtosis = -0.0224531
Stnd. kurtosis = -0.0224531
Coeff. of variation = 26.7244
Sum = 1176.0

Normal Probability Plot for Zinc



Local Background Soil Results

Sample Identifier	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury
Bkg-01-A	2700	6	2	110	ND	0.9	23000	3	3	6	5800	6	2100	190	ND
Bkg-01-B	4100	8	2	130	0.3	1.5	24000	5	4	7	8800	7	3100	230	ND
Bkg-02-A	2400	4	2	110	ND	0.8	35000	2	3	4	4400	3	2100	99	ND
Bkg-02-B	3400	7	2	130	ND	1	31000	3	3	6	6300	8	2700	210	ND
Bkg-03-A	4800	9	5	110	0.4	1.8	36000	6	5	9	11000	9	3700	210	ND
Bkg-03-B	6000	10	2	95	0.4	1.8	28000	7	5	9	11000	9	4400	250	ND
Bkg-04-A	4000	7	2	120	0.3	2.3	24000	9	4	13	9300	8	3000	190	ND
Bkg-04-B	3300	6	2	120	ND	1.4	24000	4	4	7	8300	6	2600	210	ND
Bkg-05-A	6400	13	6	210	0.5	1.8	78000	6	7	14	10000	16	5600	330	ND
Bkg-05-B	5500	10	6	140	0.5	1.7	33000	6	6	9	11000	11	3900	330	ND
Bkg-06-A	4500	9	6	150	0.3	1.5	46000	19	4	8	9100	8	3800	190	ND
Bkg-06-B	3800	8	2	150	0.3	1.1	51000	4	4	7	6800	7	3400	200	ND
Bkg-07-A	3100	6	2	95	0.3	1.1	34000.	4	4	6	7000	12	2600	170	ND
Bkg-07-B	3600	7	3	100	0.3	1.3	39000	4	4	6	7500	7	3000	180	ND
Bkg-08-A	2200	5	6	160	ND	0.6	54000	3	ND	4	4400	4	2600	110	ND
Bkg-08-B	3600	7	3	190	ND	1.6	60000	5	4	7	9500	6	4100	180	ND
Bkg-09-A	5900	11	6	210	0.4	1.7	49000	6	5	7	11000	8	5400	230	ND
Bkg-09-B	3400	7	3	210	0.3	0.9	82000	3	3	5	5500	6	3800	120	ND
Bkg-10-A	7500	11	2	140	0.3	2.3	42000	8	5	8	13000	12	3200	190	ND
Bkg-10-B	6600	11	6	150	0.3	2.6	35000	7	4	10	14000	11	3300	200	ND
Bkg-11-A	8300	13	2	200	0.4	2.2	43000	8	5	9	12000	18	3600	190	ND
Bkg-11-B	10000	16	2	200	0.5	2.4	40000	10	6	9	16000	20	4000	220	ND
Bkg-12-A	5600	11	2	200	0.3	2.2	55000	7	5	9	12000	9	4300	200	ND
Bkg-12-B	8600	14	6	290	0.4	2.6	47000	10	6	9	15000	13	5000	220	ND

Concentrations in mg/kg
Activities in pCi/g
Sample Identifier XX-XX-A - surface soil samples
Sample Identifier XX-XX-B - subsurface soil samples

Local Background Soil Results

Sample Identifier	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc	Tritium	Plutonium 239/24	Plutonium 238	Uranium-238	Uranium-235/236	Uranium-234
Bkg-01-A	4	1500	ND	ND	ND	ND	11	50						
Bkg-01-B	6	2000	ND	ND	ND	ND	16	63						
Bkg-02-A	2	730	ND	ND	ND	ND	9.6	41						
Bkg-02-B	5	1600	ND	ND	ND	ND	11	53						
Bkg-03-A	7	1500	ND	ND	ND	ND	19	56						
Bkg-03-B	9	1200	ND	ND	480	ND	15	62						
Bkg-04-A	12	1900	ND	1	ND	ND	18	55	<0.010	<0.009	<0.011	0.8	0.28	1
Bkg-04-B	5	1400	ND	ND	ND	ND	16	52	<0.022	<0.008	<0.009	0.3	0.02	0.3
Bkg-05-A	9	2700	ND	ND	ND	ND	22	37						
Bkg-05-B	8	1400	ND	ND	ND	ND	18	34						
Bkg-06-A	13	1500	ND	ND	ND	ND	16	52						
Bkg-06-B	6	800	ND	ND	420	ND	14	54						
Bkg-07-A	5	870	ND	ND	ND	ND	15	21						
Bkg-07-B	5	800	ND	ND	380	ND	15	21						
Bkg-08-A	3	730	ND	ND	ND	ND	12	33						
Bkg-08-B	5	980	ND	ND	430	ND	21	67						
Bkg-09-A	8	1100	ND	ND	280	ND	24	41						
Bkg-09-B	5	550	ND	ND	640	ND	14	44						
Bkg-10-A	6	2400	ND	ND	ND	ND	27	52						
Bkg-10-B	7	2200	ND	ND	ND	ND	27	49						
Bkg-11-A	7	2100	ND	ND	280	ND	25	60	<0.023	<0.007	<0.017		0.03	0.5
Bkg-11-B	8	2400	ND	ND	290	ND	35	64	<0.024	<0.012	<0.018		0.03	0.6
Bkg-12-A	6	1500	ND	ND	ND	ND	25	46	<0.084	<0.030	<0.017		0.17	0.8
Bkg-12-B	8	1900	ND	ND	620	ND	33	69	<0.023	0.035	0.038	0.6	0.33	0.9

Concentrations in mg/kg
Activities in pCi/g
Sample Identifier XX-XX-A - surface soil samples
Sample Identifier XX-XX-B - subsurface soil samples

Normal Parameters for Tijeras Arroyo Local Metal Background Data

Statistical Parameter	Aluminum	Antimony	Arsenic	Barium	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Manganese	Nickel	Vanadium	Zinc
median	4300	8.5	2	140	2	6	4.2	7.3	9400	7.9	200	6.2	17	52
geometric mean	4579.9	8.6	3	144	2	5	3.7	7.3	8977.5	8.5	195	6	18	47
maximum	10000	16	6	210	3	10	6.6	13	16000	20	330	12	35	69
minimum	2200	4.4	2	95	1	2	0.1	4.2	4400	3.2	99	2.4	9.6	21
arithmetic average	4970.8	9	3	149	2	5.5	4.2	7.5	9529.2	9.3	202	6.3	19	49
standard deviation	2095.4	3	2	40.5	1	2.3	1.3	2	3219.2	4.2	53.6	2.1	6.9	13
normal tolerance	2.309	2.3	2	2.33	2	2.3	2.3	2.3	2.309	2.3	2.31	2.3	2.3	2.3
UTL	4927.4	16	7	244	3	11	7.3	12	16962	19	326	11	35	79

Lognormal Parameters for Tijeras Arroyo Local Metal Background Data

Statistical Parameter	Aluminum	Antimony	Arsenic	Barium	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Manganese	Nickel	Vanadium	Zinc
arithmetic average	8.4294	2.2	1	4.97	0	1.6	1.3	2	9.1025	2.1	5.27	1.8	2.9	3.8
standard deviation	0.4126	0.3	1	0.27	0	0.5	0.8	0.3	0.3631	0.4	0.28	0.4	0.3	0.3
normal tolerance	2.309	2.3	2	2.33	2	2.3	2.3	2.3	2.309	2.3	2.31	2.3	2.3	2.3
UTL	9:3821	2.9	2	5.6	1	2.7	3.1	2.6	9.941	3.1	5.91	2.6	3.7	4.6
e^{UTL}	11874	19	10	271	4	14	21	14	20764	23	370	14	40	98

Insufficient data for mercury, selenium, silver, and thallium to calculate statistics
All concentrations in mg/kg

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Summary of Background Concentrations for Radionuclides in Soil

Analyte	Original Number of Samples	Number of Detects	Number of Rejected Samples	Distribution Type	Range (pCi/g)	n[a]	Geometric Mean (pCi/g)	Median (pCi/g)	95th Upper Tolerance Limit (pCi/g)	95th Percentile (pCi/g)
Bismuth-212	324	17	307	Nonparametric	0.414–2.7	17	1.1055	1.0	–	2.7
Bismuth-214	340	321	19	Nonparametric	0.27–1.4	321	0.648	0.6	–	0.8
Cesium-137	802	561	26	–	–	–	–	–	–	–
(Surface)	–	–	–	Nonparametric	0.004–10.1	604	0.200	0.2495	–	0.92
(Subsurface)	–	–	–	Unknown[c]	<detection limit (<0.0686)	172	<detection limit (<0.0686)	<detection limit (<0.0686)	–	<detection limit (<0.0686)
Cobalt-60	321	11	74	Unknown	<detection limit (<0.0418)	247	<detection limit (<0.0418)	<detection limit (<0.0418)		<detection limit (<0.0418)
Lead-210[b]	338	40	292	Nonparametric	0.3–12.0	46	2.26838	2.835	–	6.8
Lead-212[b]	323	233	90	Lognormal	0.1–1.4	233	0.49689	0.5	1.0795	–
Lead-214[b]	249	241	9	Lognormal	0.29–1.13	240	0.549	0.56	0.90	–
Potassium-40	722	720	4	Normal	0.192–31.0	718	15.889	16.4	25.34	–
Radium-224	24	24	0	Nonparametric	0.43–0.97	24	0.6747	0.655	–	0.968
Radium-226	368	53	314	Lognormal	0.5–2.09	54	0.713	0.590	1.94	–
Radium-228	24	24	0	Nonparametric	0.45–1.05	24	0.695	0.630	–	1.05
Radon	0	0	0	Unknown	–	0	–	–	–	–
Strontium-90	54	45	9	Nonparametric	0.032–1.85	45	0.2528	0.2883	–	0.766
Thorium-232	136	136	0	Lognormal	0.23–1.20	136	0.7971	0.810	1.258	–
Thorium-234	365	52	330	Lognormal	0.324–3.0	35	0.7796	0.71	2.89	–
Tritium	0	0	0	Unknown	–	0	–	–	–	–
Uranium-234	4	4	0	Nonparametric	0.8–1.0	4	0.897	0.9	–	1.0
Uranium-235	95	21	75	Nonparametric	0.05–0.18	20	0.1198	0.1235	–	0.168
Uranium-238	223	206	17	Nonparametric	0.0033–2.065	206	0.506	0.763	–	1.1

[a]Sample size.
[b]These constituents are not listed as COC in Table 2-2 for this media.
[c]Constituents of concern are of unknown distribution type because data are either below the limit of detection, unusable, or nonexistent.

(IT, 1994)

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